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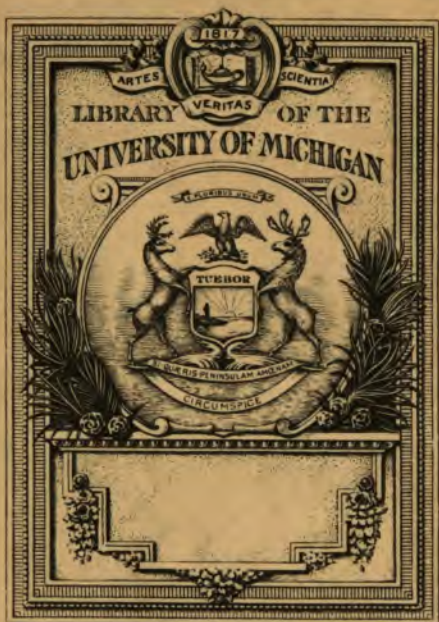
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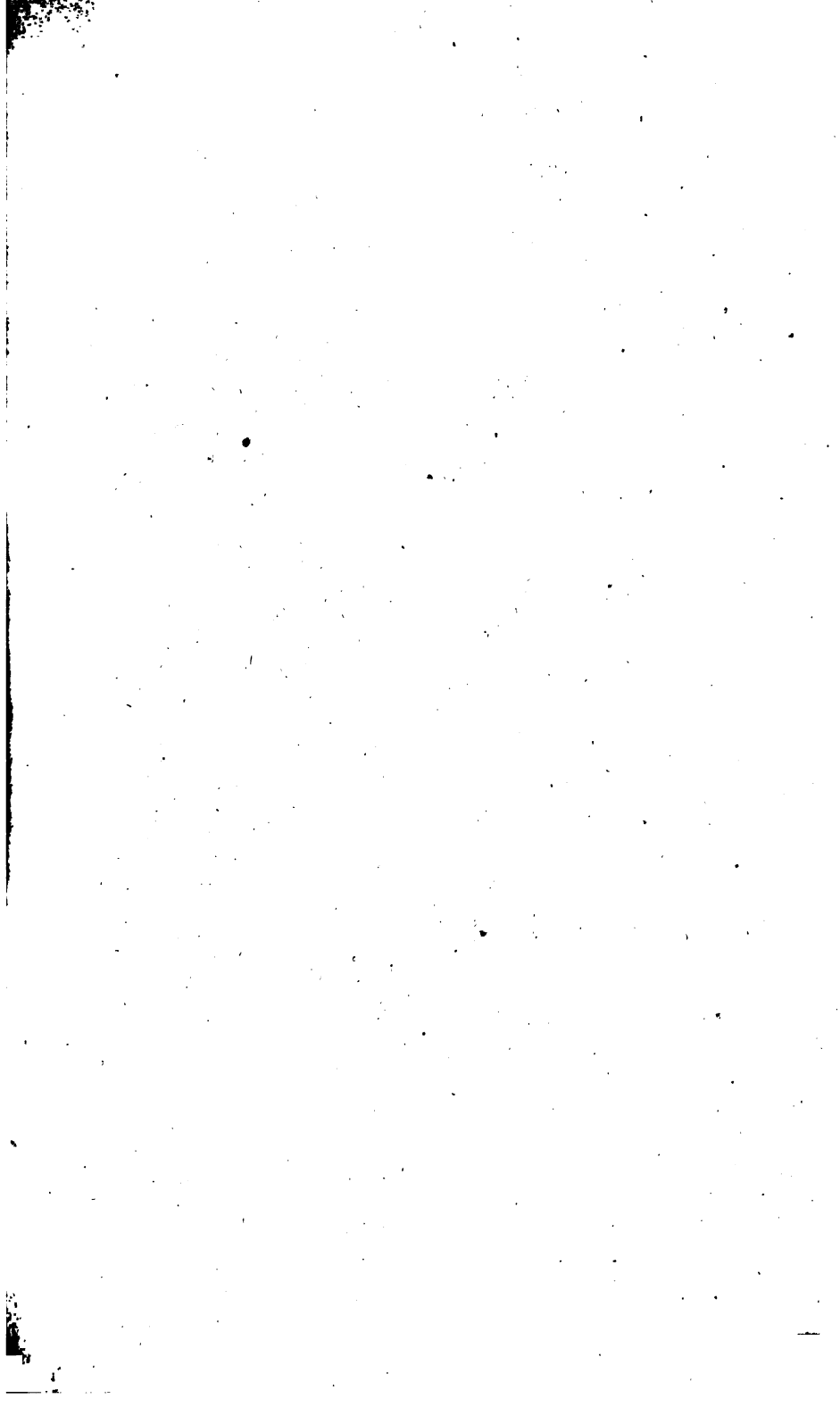
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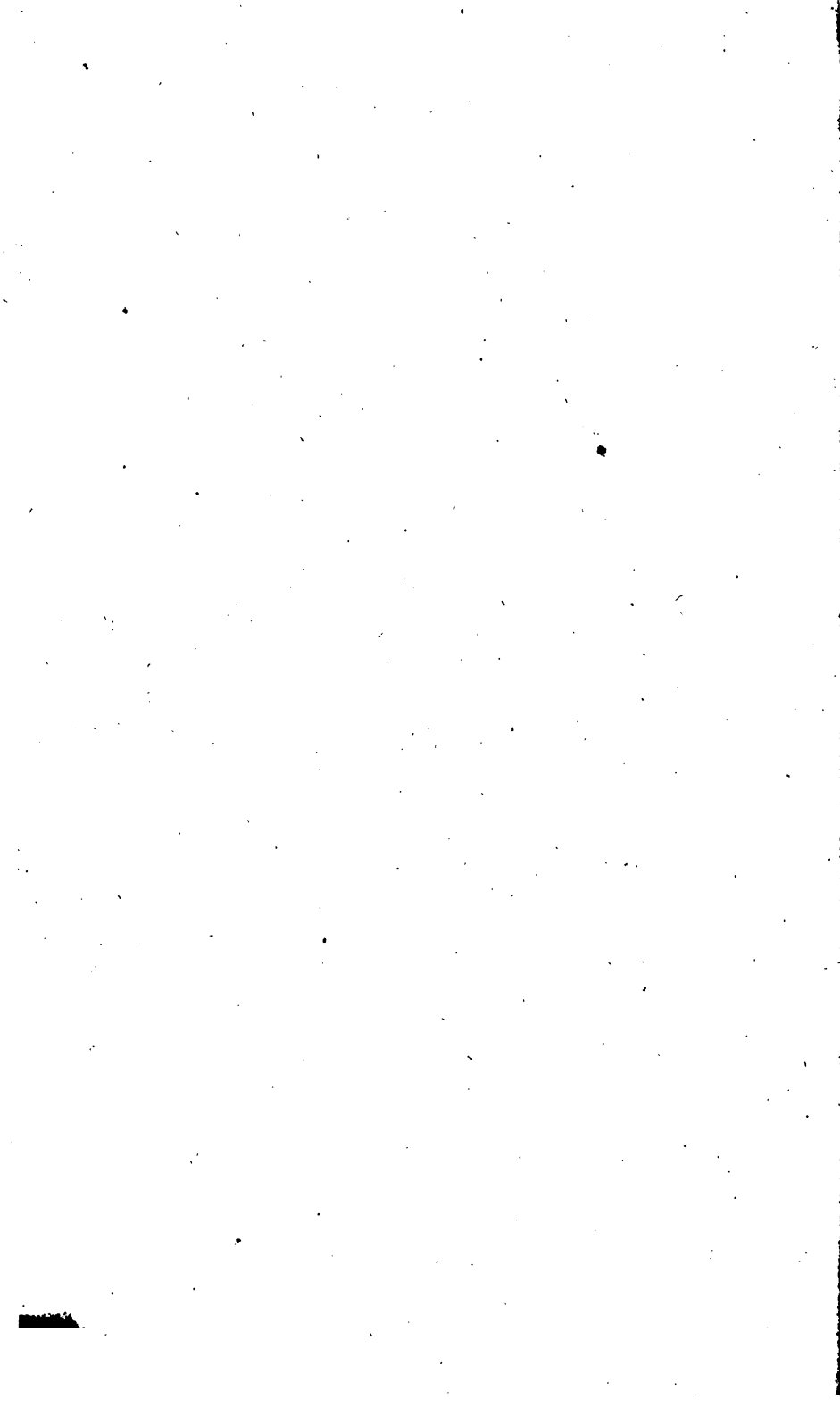
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THE
ELEMENTS
OF
EXPERIMENTAL CHEMISTRY,

BY
WILLIAM HENRY, M.D. F.R.S.

Vice-President of the Literary and Philosophical, and Natural History Societies of Manchester,
Member of the Royal Medical and Wernerian Societies of Edinburgh; the Medico-Chirurgical
and Geological Societies of London; the Physical Society of Jena; the Natural History Society
of Moscow; the Literary and Philosophical Society of New York, etc. etc.

THE SECOND AMERICAN FROM THE EIGHTH LONDON EDITION,
WITH
A SUPPLEMENT,
CONTAINING THE NEW MATTER OF THE NINTH.

THE WHOLE ILLUSTRATED WITH
FOURTEEN PLATES, AND SEVERAL ENGRAVINGS ON WOOD.

TOGETHER WITH
An Account of Dr. Wollaston's Scale of Chemical Equivalents.

ALSO,
A SUBSTITUTE FOR WOULDPE'S OR NOOTH'S APPARATUS,
AND

A Theory of Galvanism;

BY
ROBERT HARE, M.D.
Professor of Chemistry in the Medical Department of the University of
Pennsylvania.

IN THREE VOLUMES.

VOL. III.

PHILADELPHIA:
Published by Robert Desilver, No. 110 Walnut Street.
1823.

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TO THE SECOND AMERICAN,

FROM THE EIGHTH LONDON EDITION OF

DR. HENRY'S

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OF

EXPERIMENTAL CHEMISTRY:

EMBRACING ALL THE IMPORTANT ADDITIONS,

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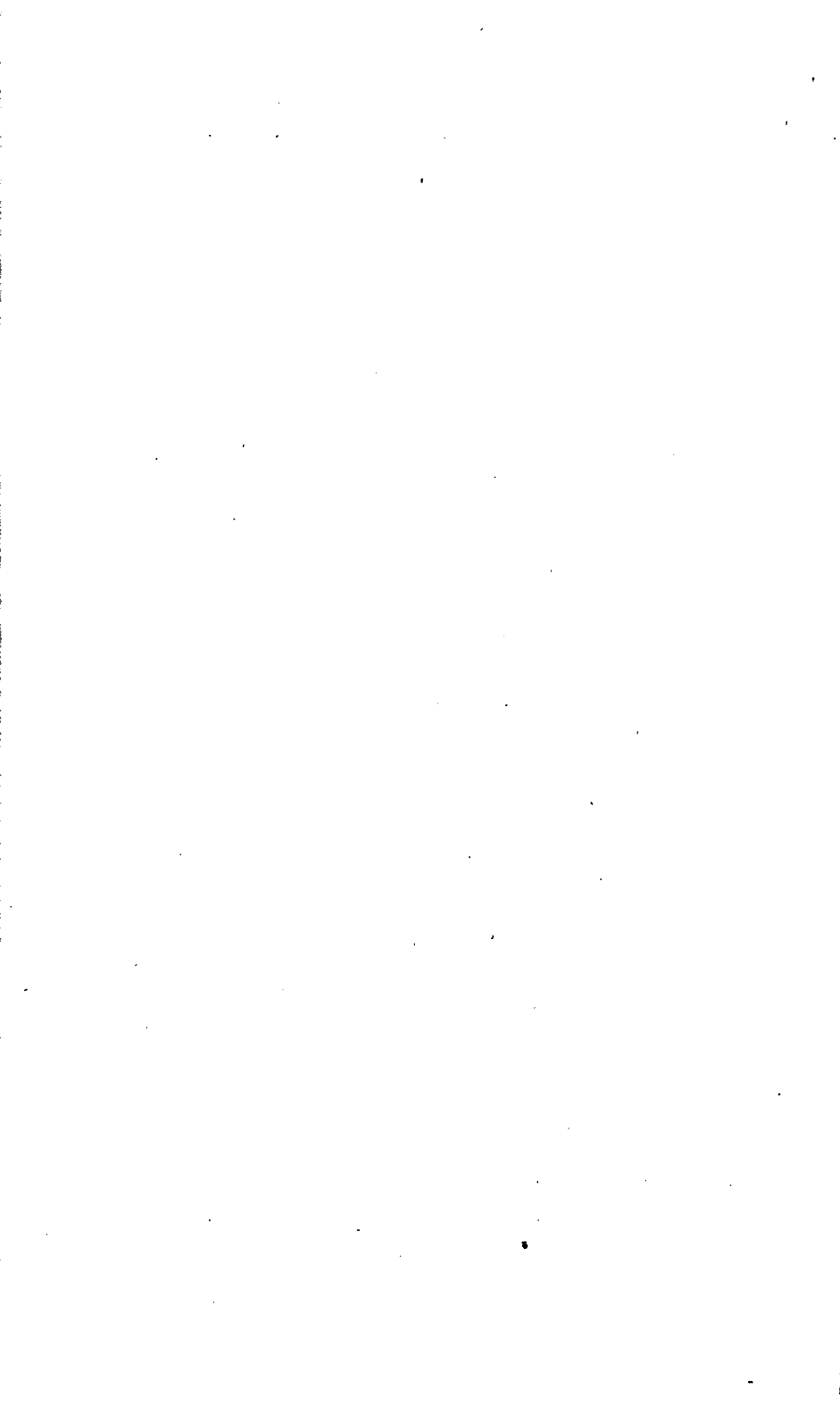
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FROM the rapid sale of the first American, from the eighth London Edition of Dr. Henry's Chemistry, with Addenda by Dr. Hare, the publisher was under the necessity, in 1822, in order to supply the public demand, to put a second edition to press, without waiting for the appearance of a new impression of the work in England, which might contain the latest improvements and discoveries in Chemical Science up to the date of publication. Foreseeing, however, the objections, which might be urged against the American edition, from the early appearance of a new English impression, under the eyes of the author, as not containing the latest improvements in the Science, the publisher determined, as soon as the new work should reach this country; to remedy this defect; and accordingly, the anticipated new English edition having made its appearance in the spring of the present year, he lost no time in making arrangements for having prepared the supplementary volume, which is now offered to the public.

No blame attaches to the publisher for not having originally delayed the republication, until the appearance of the new English edition, since the demands for the work were so urgent, as well by the students of the University of Pennsylvania, in which it is used as a text book, as by those of other public Institutions, as not to admit of being disregarded. At the same time, in presenting the new matter in a separate form, he believes he has done an acceptable service, both to the purchasers of that part of his edition, already sold, by enabling them to complete their copies with the supplementary volume, and also to those, who, while they may desire to see the latest discoveries in Chemical Science, may not wish to incur the expense of the English copy.

The preparer of the present volume has but few words to say respecting its execution. His task has consisted in extracting and arranging the new matter, with proper references to the

places in the body of the work, to which the additions may be considered to appertain. These references appeared to be necessary to enable the supplementary volume to be read in connection with the original text, and to render it a proper sequel to the volumes heretofore published. Occasionally, he has detected an error, which had escaped the author, and ventured on its correction.

Respecting the matter itself, it is believed a large portion will prove new and interesting to the scientific public. Among the more important articles are the following:—On the Condensation of Gases into Liquids—On Electro-Magnetism—On the Compounds of Hydrogen and Carbon—On the Chlorides of Carbon, recently discovered by Mr. Faraday—On Cadmium, the metal discovered by Stromeyer—On the Modes of Proceeding in the ultimate Analysis of Substances—On Native Vegetable Alkalies—On the Varieties of Coal, found in Great Britain, with their ultimate Analysis, by Dr. Thomson—On the Analysis of Mixed Gases.—&c. &c. Among the Additions to the Appendix, will be found a copious list of Equivalent Numbers and a condensed view, in the tabular form, of the principal characters of the Earths and Metallic Oxides before the Blowpipe, taken from Berzelius's work on this subject,—tables of indispensable utility to the analytic Chemist and Mineralogist.

November 1823.

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ADDITIONS TO THE CHAPTER ON CALORIC.—PART I. CHAP. III.*

Radiation from the Surface of the Earth, &c.—Vol. I. p. 76.*

THE movement of caloric by radiation appears to be the same through all the different varieties of æriform bodies; though, as will afterwards appear, the gases differ materially from each other in their *conducting power*. Caloric, also, radiates from bodies at all temperatures, but the quantity radiated bears some proportion to the excess of the temperature of the hot body above that of the surrounding medium. Hence, if we have any number of bodies at different temperatures in the vicinity of each other, they may all, agreeably to the ingenious theory of M. Prevost, be considered both as radiating and receiving caloric; but the hot ones will radiate more than they receive, while the cold ones will receive more than they radiate.

The process of radiation appears to be constantly going on from the surface of the earth, and it is partly on this principle that we are to explain why the heat, which our planet is incessantly receiving from the sun, does not accumulate to such a degree as to render it a less fit habitation for man. The period, when radiation from the surface of the globe is most discoverable by its effects, seems to be during the night, especially when the sky is perfectly unclouded; for a covering of clouds serves as a mantle to the earth, and prevents the free escape of radiant heat. Under favourable circumstances, it has been shown by Dr. Wells, that

* The references to Parts and Chapters note the particular divisions of the body of the work, to which the new matter appertains; while the references to Volume and Page indicate the exact place in the edition of *Hare's Henry's Chemistry*, where the additions may be considered to belong. These marks will afford facilities to the reader, who wishes to peruse the new matter in connection with the corresponding subjects of the body of the work.—B.

the temperature of the ground, especially when its covering is formed of some substance that radiates freely, is several degrees below that of the atmospheric stratum, a few feet above it. It is this diminished temperature of the earth's surface, that occasions the deposition of dew and hoar frost, which are always observed to be most abundantly formed under a clear unclouded sky.

Expansion of Bodies by Caloric:—Metallic Thermometers of Breguet and Daniell, &c.—Vol. I. p. 79.

THE metallic thermometer of M. Bréguet consists of a slip of silver and another of platina coiled into a spiral, one end of which is fixed, while the other is connected with an index which traverses a circular graduated plate. This instrument is capable not only of measuring, distinctly, variations of temperature too slight to be shown by a common thermometer, but also of being affected by changes too transient to be perceived even by an air thermometer. Mr. Daniell has, also, availed himself of the same property of expansion, in constructing a thermometer for measuring high degrees of heat. A bar of platina is inclosed in a case made of the same ware as black-lead crucibles, and is fixed to it at one end, while the other is left free to move an index, by which means degrees of heat above ignition admit of being accurately measured. (Jour. of Science, xi. 309.) The experiments of Dr. Ure (Phil. Trans. 1818) tend to show, that equal degrees of expansion are produced in a bar of metal, by a succession of similar increments of heat. Thus if the absolute elongation of a metallic rod heated from 32° to 122° , be called 10, then its elongation, by each of four successive intervals of 90° Fahr., was, as nearly as possible, 10 also.

The expansion of metals produces important effects in various mechanical instruments, especially in clocks; for a pendulum vibrating seconds will, by a change of temperature equal to 30° Fahr., alter its length about $\frac{1}{3000}$ th part, which is sufficient to change its rate of going eight seconds of time per day. To obviate this inconvenience, various contrivances have been resorted to, which are described in works on practical horology.

Howard's Differential Thermometer.—Vol. I. p. 81.

A differential thermometer has been contrived by Dr. Howard, resembling that of Mr. Leslie in its general form, but in which the degree of heat is measured by the expansive force of the vapour of ether or spirit of wine *in vacuo*. Directions for constructing it are given in the 8th vol. of the Quarterly Journal of Science, p. 219. It is intended to be applied to the same purposes as that of Mr. Leslie, but is more sensible to changes of

temperature, and the movement of the fluid (ether tinged by a drop of tincture of cochineal) follows instantaneously the application of the heating cause; whereas in the air thermometer some time is required before the effect takes place.

Increasing Rate of Expansion of Mercury at High Temperatures.—Vol. I. p. 85.

THE view which has been taken by Mr. Dalton of the thermometer, has drawn the attention of Dr. Ure, and of M. M. Petit and Dulong, to the same subject. The former concludes from his experiments, that, taking three thermometric intervals from 32° Fahr. upwards, each of 180°, mercury has actually an increasing rate of expansion, and that 60 parts at 572° are expanded as much by the same power of caloric, as 61 parts at 392°, and 62 parts at 212°. But this small difference, he observes, is compensated by the lessening quantity of quicksilver in the bulb of a thermometer at high temperatures, in consequence of which the mercurial thermometer becomes a true measurer of sensible heat. Petit and Dulong, also, satisfied themselves, that the expansibility of mercury slowly increases as the temperature augments. From 32° to 212°, it is scarcely appreciable, and corresponds with the expansion of air, which they take for granted to be perfectly equable. The following Table exhibits the dilatation of mercury for a degree centigrade at the various temperatures (all centigrade) indicated in the first column of the table, and measured by an air thermometer.

Temperature.	Expansion of Mercury.	Temp. indicated by the dilatations of the mercury, supposed uniform.
0°	0	0.00
100	$\frac{1}{5556}$	100.00
200	$\frac{1}{555}$	204.61
300	$\frac{1}{556}$	314.15

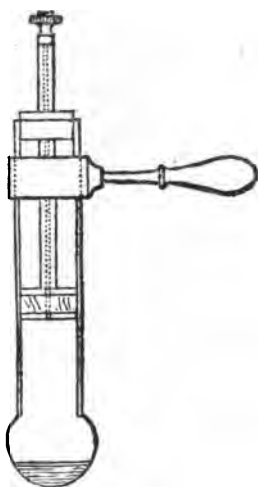
Comparing the numbers in the first and last columns, it appears that up to 100°, the mercurial and air thermometers give the same indications; in the second interval, the excess of the former over the latter is 4.61°, and in the last interval it increases to 14.15°.

The boiling point of mercury, according to these philosophers, is 680° Fahr., or, making the due correction for the expansion of glass, 662° of Fahr. scale. The experimental result of Mr. Crichton of Glasgow, was 656°.

Transparency and Elasticity of Steam.—Vol. I. p. 96.

THE perfect transparency of steam, and also two other important properties on which depends its use as a moving power,

viz. its elasticity and its condensibility by a reduced temperature, are beautifully shown by a little apparatus contrived by Dr. Wollaston, of which a sketch is annexed. It consists of a glass tube about 6 inches long and $\frac{3}{4}$ inch bore, as cylindrical as possible, and blown out a little at the lower end. It has a wooden handle, to which is attached a brass clip embracing the tube; and within is a piston, which, as well as its rod, is perforated, as shown by the dotted lines. This canal may be occasionally opened or closed by a screw at the top; and the piston rod is kept in the axis of the cylinder by being passed through a piece of cork fixed at the top of the tube. When the instrument is used, a little water is put into the bottom; the piston is then introduced with its aperture left open; and the water is heated over a spirit lamp. The common air is thus expelled from the tube, and when this may be supposed to be effected, the aperture in the rod is closed by the screw. On applying heat, steam is produced, which drives the piston upwards. On immersing the bulb in water, or allowing it to cool spontaneously, a vacuum is produced in the tube, and the piston is forced downwards by the weight of the atmosphere. These appearances may be alternately produced by repeatedly heating and cooling the water in the ball of the instrument. In the original steam engine, the vapour was condensed in the cylinder, as it is in the glass tube; but in the engine as improved by Mr. Watt, the steam is pumped into a separate vessel, and there condensed; by which the loss of heat, occasioned by cooling the cylinder every time, is avoided.



Elasticity of Vapours.—Vol. I. p. 98.

It is evidently unnecessary that a liquid should boil *in vacuo*, in order to be converted into vapour; for all liquids have in fact, at every temperature, a tendency to assume the state of gas, and several, which exhibit, at the common temperature of the atmosphere, no appearance of ebullition, are nevertheless convertible into vapour, at that temperature, under an exhausted receiver. The quantity of vapour produced *in vacuo*, varies with the space, the temperature, and the nature of the liquid. 1st, It is proportional to the space: for a double space gives occasion to the formation of a double quantity of vapour; and if a given volume of vapour be mechanically compressed into half its bulk, one-half will be re-converted into water. 2dly, It increases with the temperature, but in a greater proportion. 3dly, It is different for dif-

ferent liquids; and it may be observed that liquids, which enter most easily into ebullition, are generally, though with some exceptions, those which at a given temperature afford the densest vapour. Thus the vapour of ether is more dense than that of water. The caloric required to produce this sort of evaporation, which may be called *spontaneous*, in order to distinguish it from that produced by obvious sources of heat, is supplied in the first instance by the liquid itself, the temperature of which is observed to fall, and is regained by contact with surrounding bodies.

Spontaneous evaporation goes on, also, from the surface of liquids exposed to the atmosphere, and a quantity of vapour is produced which, from the same liquid, is determined by the pressure and the temperature. If to a given volume of dry atmospheric air confined over mercury, we admit a small quantity of water, the volume of the air is increased by the admixture of aqueous vapour. Substituting at the same temperature and pressure, any other gas for atmospheric air, an expansion is produced to precisely the same amount; and it is remarkable that the quantity and force of vapour, in a given volume of air or of gas of extreme moisture, is precisely the same as in a Toricellian vacuum of like volume. These facts show, as will afterwards more fully appear, that spontaneous evaporation is entirely independent of any affinity of air for water, and is to be explained by the general laws regulating the production and force of vapour.

Conversion of Liquids into Vapours under Strong Pressure.—

Vol. I. p. 98.

It is well known, that, by means of a Papin's digester, we are enabled to raise the temperature of liquids considerably above the points, at which they boil under the mean pressure of the atmosphere; and it seemed probable, that the internal pressure, augmenting with the temperature, must effectually prevent the total volatilization of the liquid, especially if the space, left above the liquid, is not of a certain extent. But, provided sufficient space is allowed for the generated vapour, it appeared to Mr. Cagniard de la Tour a necessary consequence, that there should be a limit, beyond which these liquids ought, notwithstanding the pressure, to be completely volatilized; and to verify this opinion, he was led to make some interesting experiments.

A strong glass tube, containing about two-fifths its capacity of alcohol, sp. gr. .837, being carefully heated, the alcohol continued to expand, till, after having attained nearly double its original volume, it was converted into vapour so transparent, that the tube appeared completely empty. Allowing it to cool, the alcohol was again condensed into a liquid. When the proportion of the alcohol to the capacity of the tube was increased, the consequence was, the bursting of the tube. Similar results were obtained with naphtha and ether, the latter requiring less space than the former, for

being converted into vapour without breaking the tube; and the naphtha, less space than the alcohol. No difference was occasioned by the pressure of atmospheric air in the tubes, or its exclusion from them, except that the ebullition of the liquid was then much more moderate.

The same success did not attend the first attempt to convert water into vapour; for when a tube, about one-third filled with water, was similarly heated, it burst with an explosion. The inner surface of the glass tube appeared also to have been acted upon, its transparency being impaired.

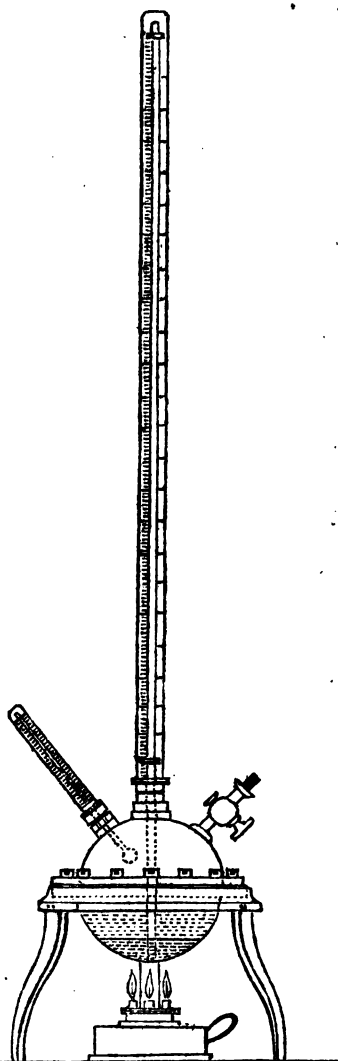
M. de la Tour afterwards determined, by means of a guage, which measured the bulk of a confined portion of air, subjected, through the intervention of a column of quicksilver, to the pressure of the generated vapour, the density of the latter. Alcohol, converted into vapour, and occupying a space a little exceeding three times its original volume, he found to exert a pressure = 119 atmospheres, and to require a temperature of 404.6° Fahrenheit. Ether, under the same circumstances, required a temperature of 320° Fahrenheit, and the force of its vapour was equivalent to 37 or 38 atmospheres. Water, to which a minute quantity of carbonate of soda had been added, ceased to act upon glass tubes; and though several tubes were broken, it was ascertained, that water itself may be converted into vapour, provided the space exceed its volume about four times. (*Annales de Chimie et de Phys.* xxi. 127, 128, or *Ann. of Philos.* v. 290.)

Experimental Determinations of the Elastic Force and Latent Heat of Vapours.—Vol. I. p. 98.

AN apparatus, adapted to show the elastic force of aqueous vapour in inches of mercury at different temperatures, has been contrived by Dr. Marcet, and may be procured from the makers of philosophical instruments in London. It consists of two hemispheres, (see the figure), generally of brass, which are fixed together by flanches and screws. At the upper part are three openings, into one of which a cock may be screwed; into the other, a thermometer, graduated to 250° , or upwards; and into the central one is fixed a long glass tube, open at both ends, and reaching to within about one-eighth of an inch of the bottom of the boiler.

When the apparatus is used, mercury sufficient to fill the tube is first put into the vessel, and over this a quantity of water sufficient to occupy about half its capacity is poured, and the cock being shut, the heat of a spirit lamp with three or four wicks is applied. With this boiler precisely the same experiments may be made as with that which is described in the body of the work, Vol. I. p. 98; the only difference being in its form, and in the gauge for measuring the force of the steam which is generated; for this, by its pressure, drives the mercury up the tube, and, by the height of the column, exhibits, in a more striking manner, the correspondence between the elasticity of the steam and its temperature.

The elasticity of the vapour of water from 32° to 212° Fahr. had been experimentally determined by Mr. Dalton, who, from his results, had calculated its force at temperatures above the ordinary boiling point. It was still, however, desirable to ascertain, by actual experiment, the elastic force of vapour above 212° , and this has been attempted by Professor Robison, Mr. Southern, and Dr. Ure. Mr. Southern's experiments were made many years ago, but were not published till very lately, in Dr. Brewster's edition of Prof. Robison's Works. The following table expresses the elasticity of aqueous vapour according to his experiments, under one, two, four, and eight atmospheres.



Atmospheres.	Pressure in Inches of Mercury.	Temperature Fahr.
1	29.8	212°
2	59.6	250.3
4	119.2	293.4
8	238.4	343.6

Dr. Ure's experiments were published in the Philosophical Transactions for 1818, and their general results are contained in a table, which will be found, along with other tabular matter, at the end of this supplement. Between 32° and 212° , an almost exact coincidence may be observed between the experiments of Dalton and of Ure; but this ceases above the boiling point of water; for there Mr. Dalton's numbers were calculated on the presumption that the same law of progression obtains in the higher as in the lower ranges, which does not appear to be correctly the fact.

Dr. Ure has examined also, the elastic forces of the vapours of alcohol, ether, oil of turpentine, and naphtha, and has exhibited the results in the form of a table. To the experiments on ether, it has, however, been objected by Mr. Dalton, that they were made on that fluid in an impure state, as is evident from its boiling point, which Dr. Ure states at 104° or 105° ; whereas the point, at which pure ether boils under the pressure of the atmosphere, is 96° Fahr.

The density of steam is nearly, if not accurately proportional to its elasticity; at least this may be affirmed of it within the limits of Mr. Southern's experiments, which extended to steam formed under a pressure of 120 inches of mercury, or of four atmospheres. Thus steam of elasticity = 40 inches of mercury, required 1.430 cubic inches of water to form each cubic foot of steam; vapour of 60 inches required 2.940 cubic inches of water; and vapour = 120 inches force required for each cubic foot 4.279 cubic inches of water. The elasticities, therefore, and the quantities of water, in these experiments, have the same common multiple; in other words, steam of double, triple, &c. elastic force contains, in an equal volume, twice, thrice, &c. the weight of water.

The latent heat of the vapours of fluids, though constant for vapour of the same kind, and of a given elasticity, differs in different vapours. The latent heat of the vapours of different liquids has been investigated, so far as I know, only by Dr. Ure. His method was to distil off a known quantity of each liquid, and to observe the temperature gained by the water employed to condense its vapour. From the results, he has constructed the following Table. (Phil. Trans. 1818).

General Table of latent Heat of Vapours.

Vapour of water at its boiling point	967°
alcohol (sp. gr. 0.825)	442
sulph. ether (boiling point 104°)	302.379
petroleum	177.87
oil of turpentine (do. about 310°)	177.87
nitric acid (sp. gr. 1.494, boiled at 165°)	531.99
liquid ammonia (sp. gr. 0.978)	837.28
vinegar (sp. gr. 1.007)	875.00

Specific Gravity of Aqueous Vapour.—Vol. I. p. 100.

THE specific gravity which aqueous vapour ought to have from theory is 0.620, for this should result from condensing, into two

volumes, two volumes of hydrogen gas, sp. gr. 0.0688, and, one volume of oxygen gas, sp. gr. 1.1025. The experimental result of Gay-Lussac was obtained by comparing air and steam at the common temperature of 212° Fahr. But as all gases and vapours are expanded or contracted to the same amount by equal variations of temperature, it must be obvious that the same relation will continue between air and aqueous vapour at all other degrees of heat, provided both are subjected to a common temperature and pressure.

Latent Heat of Steam under higher Pressures than that of the Atmosphere.—Vol. I. p. 103.

DIRECT experiments to ascertain the latent heat of steam, formed under higher pressures than that of the atmosphere, have been made by Mr. Southern, of Soho, and by Mr. Sharpe, of Manchester. Those of the latter were first published; but were subsequent in point of time to the experiments of Mr. Southern, which, though only lately made public, were instituted many years ago. They consisted in ascertaining the augmentation of weight and increase of temperature, gained by a given quantity of water, from the condensation of known volumes of aqueous vapour of different densities. The results presented slight differences in the latent heat of steam of different densities, but of so small an amount as to arise probably from unavoidable sources of error. The following table exhibits the principal results obtained by Mr. Southern.

Temperature of Steams.	Elasticity of ditto in inches of Mercury.	Latent Heat.
229	40	942°
270	80	942°
295	120	950°

The experiments of Mr. Sharpe, and also a recent series by Clement and Desormes, (of which an abstract is given in the Appendix to Thenard's *Traité de Chimie*, vol. iv. p. 262, 3d edition), establish the same general law. This law is of great importance in practice, since it shows that no essential saving of fuel can be reasonably expected from using, as a moving power, steam formed under high pressures. On the contrary, it seems probable that the higher the temperature of the water in the boiler, the greater will be the loss of heat by the escape of hot air through the chimney. Nevertheless, there are certain cases in which high pressure steam may be advantageously applied to various manufacturing processes, as a means of communicating heat, when the temperature is required to exceed 212° Fahrenheit.

A remarkable fact has been observed respecting steam of great elasticity; viz. that when allowed to escape suddenly from a cock or small aperture in the boiler, the hand may be held close to the

place at which it issues, without being scalded by it; and even the water of the boiler itself does not scald under these circumstances. Both the issuing steam and water must, necessarily, therefore, be considerably under the temperature of 212° , and are, in fact, found to be so by the thermometer. This is probably owing to the sudden rarefaction of the issuing steam in the first case, or sudden production of steam of great rarity in the second; for this rarefaction, or sudden production of steam, instantly renders latent a large quantity of heat, and prevents it from producing those effects, which are due only to caloric of temperature. There is still, however, some difficulty in conceiving, why highly compressed steam, on being allowed to escape from an orifice, should fall below 212° , since that is the temperature which is due to it under the mean pressure of the atmosphere.

Specific Heats of Bodies at different Temperatures, &c.—
Vol. I. p. 106.

It has been doubted whether the specific heats of bodies are permanent so long as they retain their form; in other words, whether a quantity of heat, which raises a body through a certain number of degrees at any one temperature, will raise it through an equal number of degrees at other temperatures. This subject, to which Mr. Dalton had formerly turned his attention, has been lately investigated more completely by Petit and Dulong. They heated the body to be tried to the required temperatures, and ascertained what number of degrees of heat it communicated to a certain quantity of water. Repeating these trials at various points of the thermometric scale, they found that the specific heats of bodies are greater at high than at low temperatures. Thus the specific heat of iron was found to be as follows:

Centigrade.	Specific Heat.
From 0 to 100°	0.1098
0 to 200°	0.1150
0 to 300°	0.1218
0 to 350°	0.1255

The same law was found to extend to various other bodies, as is shown by the following Table:

	Sp. heats between 0° and 100° Centigr.	Sp. heats between 0° and 300° Centigr.
Mercury	0.0330	0.0350
Zinc	0.0927	0.1015
Antimony	0.0507	0.0549
Silver	0.0557	0.0611
Copper	0.0949	0.1013
Platinum	0.0355	0.0355
Glass	0.1770	0.1900

Another important law, deduced by Petit and Dulong, from their researches on heat is, that *the atoms of all simple bodies have precisely the same specific heat*. This will appear from the following Table, the third column of which expresses differences so small, that they may reasonably be imputed to unavoidable inaccuracies in the method of determining the true weights of the atoms.

	Sp. heats, that of wa- ter being 1	Weight of the atoms, that of oxy- gen being 1.	Product of the w'ght. of the atom by the Sp. heat.
Bismuth	0.0288	13.300	0.3830
Lead	0.0293	12.950	0.3794
Gold	0.0298	12.430	0.3704
Platinum	0.0314	11.160	0.3740
Tin	0.0514	7.350	0.3779
Silver	0.0557	6.750	0.3759
Zinc	0.0927	4.030	0.3736
Tellurium	0.0912	4.030	0.3675
Copper	0.0949	3.957	0.3755
Nickel	0.1035	3.690	0.3819
Iron	0.1100	3.392	0.3731
Cobalt	0.1498	2.460	0.3685
Sulphur	0.1188	2.011	0.3780

Taking water as unity, the specific heats of the gases are as follow:

TABLE OF THE SPECIFIC HEATS OF THE GASES, WATER BEING TAKEN AS UNITY.

Water	1.0000
Atmospheric air	0.2669
Hydrogen gas	3.2936
Carbonic acid	0.2210
Oxygen	0.2361
Azote	0.2754
Protoxide of azote	0.2369
Olefiant gas	0.4207
Oxide of carbon	0.2884
Steam of water	0.8470

After having thus determined the specific heats of the gases, MM. de la Roche and Berard ascertained that the specific heat of any one gas, considered with respect to its volume, augments with its density, but in a proportion less than the increase of density. On this subject, MM. Clement and Desormes have given the following results:

	Under the pressure of in. of mer.	Sp. heat.
Atmospheric air	39.6	1.215
Ditto	29.84	1.000
Ditto	14.92	0.693
Ditto	7.44	0.540
Ditto	3.74	0.368
Azotic gas	29.84	1.000
Oxygen	29.84	1.000
Hydrogen	29.84	0.664

ADDITIONS TO THE CHAPTER ON LIGHT—PART I.
CHAP. IV.

*Refractive Power of different Gases.—Double Refraction:—
Polarization of Light.*—Vol. I. p. 106.

IN general the amount of refraction is proportional to the density of a body, but inflammable substances cause a greater refraction than might have been inferred from their densities, and the refractive power of the same inflammable substance bears a proportion to its perfection, insomuch that this property may be used as a test of its purity. Thus Dr. Wollaston found that genuine oil of cloves has a refractive power of 1.535, while that of an inferior quality did not exceed 1.498. The powers of the gases to refract light are exhibited in the following table by MM. Biot and Arago, from which it appears that the combustible gases surpass the others in this property, and that hydrogen gas exceeds them all.

TABLE OF THE REFRACTING POWERS OF DIFFERENT GASES.
(THERM. 32° FAHR.—BAR. 30 IN.)

Atmospheric air	1.00000
Carbonic acid	1.00476
Azotic gas	1.03408
Muriatic acid gas	1.19625
Oxygen gas	1.86161
Carburetted hydrogen	2.09270
Ammonia	2.16851
Hydrogen gas	6.61436

There are certain bodies, (Iceland spar for example), which exhibit a double image of any object that is viewed through them, or are said to *refract doubly*. In this case, one portion of the light is refracted according to the common law, the other undergoes an extraordinary refraction, in a plane parallel to the diagonal which joins the two obtuse angles of the crystal. If the ray, which has thus suffered double refraction, be made to fall on another crystal placed parallel to the first, no new division of the rays will happen; but if the second crystal be placed in a transverse direction, that part of the ray, which before suffered ordinary refraction, will now undergo extraordinary refraction; and that which underwent extraordinary refraction will now suffer ordinary refraction.

A ray of light, falling upon a polished surface of glass at an angle of $35^{\circ} 25'$, is reflected in a straight line at the same angle. But if a second plate of glass be so placed that the reflected ray will fall upon it likewise at an angle of $35^{\circ} 25'$, and if the second plate be slowly turned round its axis, without varying the angle which it makes with the ray that falls upon it, a curious phenomenon is observed. If the planes of reflection be parallel to each other, the ray of light is reflected from the second glass in the same manner as from the first. But if the second glass be turned round a quadrant of a circle, so as to make the planes of reflection perpendicular to each other, the whole of the ray will pass through the second glass, and none of it will be reflected. When the second glass is turned round another quadrant of a circle, so as to make the reflecting planes again parallel, the ray will be reflected by the second glass as at first; but when turned round three quadrants, the whole light will be again transmitted, and none of it reflected. Under certain circumstances, therefore, light can penetrate through glass when in one position, but not in another. In the latter case, it has been termed by Malus *polarised light*, on the supposition, that the light has been bent into another position, as the needle is by a magnet. For a popular statement of the discoveries of Malus, the reader is referred to the 33d vol. of Nicholson's Journal, p. 344; for those of Dr. Brewster to the Phil. Trans. for 1813 and following years; and for the experiments of Biot and Arago to the 94th vol. of the Annales de Chimie, or to the *Traité de Physique* of the former philosopher.

Analysis of Light by the Prism.—Vol. I. p. 107.

Dr. Wollaston has found, that when a beam of light only $\frac{1}{16}$ th of an inch broad is received by the eye, at the distance of ten feet, through a clear prism of flint glass, only four colours are seen, viz. red, yellowish-green, blue, and violet. The different coloured rays, being collected by a lens into a focus, again produce uncoloured light.

Modification of Leslie's Photometer.—Vol. I. p. 111.

MR. BRANDE has ascertained that by substituting ether for air, as in Dr. Howard's modification of the differential thermometer, the sensibility of Mr. Leslie's photometer is greatly increased, and that it becomes most delicately susceptible of the impression of light. An instrument of this sort he found fully adequate to determine the comparative illuminating powers of different gases, which cannot be done when the photometer is filled with air.

ADDITIONS TO THE CHAPTER ON GASES.—PART I.
CHAP. V.

Comparative Refrigerating Powers of the different Gases.—
Vol. I. p. 119.

WHEN a body heated to a certain point is placed in different gases, under circumstances otherwise similar, it is found to cool with very different velocities; in other words, the *power of elastic fluids to conduct heat differs for different gases*. Mr. Dalton has given a series of experiments on this subject, and Sir H. Davy, having raised the same thermometer to the same temperature, 160° Fahr., exposed it to equal volumes (21 cubic inches) of the following gases at 52° Fahr.

The times for cooling down to 106° were for

	Min.	Sec.
Atmospheric air	2	0
Hydrogen	0	45
Olefiant gas	1	15
Coal gas	0	55
Azote	1	30
Oxygen	1	47
Nitrous oxide	2	30
Carbonic acid	2	45
Chlorine	3	6

It appears from this table that the powers of elastic fluids to abstract or conduct away heat from solid surfaces, is in some inverse ratio to their density. The nature of the surface of the hot body, it has been shown by Dulong and Petit, does not affect the conducting power of gaseous bodies; but the state of the gases themselves, as to moisture or dryness, has a considerable influence; for moist gases, as is shown by Count Rumford's experiments, conduct heat much more rapidly than dry ones.

The following table is to a certain extent the same as that given in the body of the work, Vol. I. p. 120; but being much more copious than the old table, and made up from later researches, it is thought important to insert it in this supplement.—B.

TABLE OF THE SPECIFIC GRAVITY OF GASES.

Barometer 30. Thermometer 60°.

NAMES OF GASES.	Specific Gravity.	Wt. of 100 Cub. inches.	Authorities.
		Grains.	
Atmospheric air	1.0000	30.50	Shuckburgh.
Ditto	1.0000	30.199	Brande.
SIMPLE GASES.			
Oxygen	1.1088	33.82	Allen and Pepys.
Ditto	1.1111	33.888	Thomson.
Ditto	1.1026	33.629	Berzelius and Dulong.
Chlorine	2.5082	76.500	Davy.
Ditto	2.5000	76.250	Thomson.
Iodine (vapour)	8.678	244.679	Gay-Lussac.
Hydrogen	0.0694	2.116	Thomson.
Ditto	0.0688	2.098	Berzelius and Dulong.
Nitrogen	0.9722	29.652	Thomson.
Ditto	0.9760	29.768	Berzelius and Dulong.
Carbon (vapour)	0.422	12.870	Gay-Lussac.
Sulphur (ditto)	1.1111	33.888	Thomson.
Phosphorus (ditto)	0.8333	25.416	Ditto.
COMPOUND COMBUSTIBLES.			
Ammonia	0.5960	18.18	Allen and Pepys.
Ditto	0.5931	18.08	Thomson.
Ditto	0.5912	18.03	Berzelius and Dulong.
Carburetted hydrogen	0.5555	16.944	Thomson.
Ditto	0.5590	17.049	Berzelius and Dulong.
Bi-carburetted ditto (olefiant)	0.9722	29.652	Thomson.
Ditto	0.9804	29.90	Berzelius and Dulong.
Phosphuretted hydrogen	0.9722	29.652	Thomson.
Bi-phosphuretted ditto (hydro-phos.)	0.9653	29.441	Ditto.
Sulphuretted hydrogen	1.1805	36.007	Ditto.
Sulphuret of carbon	2.6447	80.663	Ditto.
Arsenuretted hydrogen	0.5290	16.130	Tromsdorff.
Cyanogen	1.8055	55.069	Gay-Lussac.
Ditto	1.8188	55.473	Berzelius and Dulong.
Ether, sulphuric (vapour)	2.5808	78.714	Berzelius and Dulong.
— muriatic (ditto)	2.2190	67.679	Thomson.
— hydriodic (ditto)	5.4750	166.987	Ditto.

* Dr. Thomson's elaborate paper on this subject is printed in the 16th vol. of the *Annals of Philosophy*; and Berzelius and Dulong's, in the 15th volume of *Annales de Chim. et de Physique*.

TABLE OF GASES CONTINUED.

NAMES OF GASES.	Specific gravity.	Wt. of 100 cub. inches.	Authorities.
<i>Compound Combustibles continued.</i>		Grains.	
Ether, chloric (ditto)	3.4750	105.257	Thomson.
Alcohol (ditto)	1.6004	48.812	Berzelius and Dulong.
Turpentine, oil of (ditto)	5.0130	152.896	Thomson.
OXIDES.			
Aqueous vapour	0.6235	19.016	Gay-Lussac.
Nitrous oxide	1.5277	46.597	Thomson.
Ditto	1.5273	46.582	Berzelius and Dulong.
Nitric oxide	1.0416	31.770	Thomson.
Ditto	1.0010	30.530	Berzelius & Dulong.†
Carbonic oxide	0.9722	29.652	Thomson.
Ditto	0.9727	29.667	Berzelius and Dulong.
ACIDS.			
Carbonic	1.5277	46.597	Thomson.
Ditto	1.5240	46.481	Berzelius and Dulong.
Chlorocarbonic (Phosgene)	3.4722	105.902	Thomson.
Chlorocyanic (vapour)	2.1520	65.636	Ditto.
Fluoboric	2.3709	72.312	Ditto.
Fluo-silicic	3.5735	108.002	Ditto.
Hydriodic	4.3750	133.434	Ditto.
Hydro-cyanic (vapour)	0.9368	28.572	Ditto.
Muriatic	1.2847	39.183	Ditto.
Nitric	2.4250	73.96	Sir H. Davy.
Sulphurous	2.2222	67.777	Thomson.
Sulphuric (vapour)	2.7777	84.698	Ditto.

Escape of Compressed Gases through Apertures of various Diameters.—Vol. I. p. 123.

THROUGH small needle holes, hydrogen gas, pressed by a small column of mercury, escaped about three times more quickly than olefant gas. Increasing the pressure, the same proportions were observed; and also, though not to the same degree, when the gases were expelled through slits cut by a penknife. Both glass and metal tubes produced the effect, and it was heightened as the gas was made to pass more slowly through the tube, and this, whether the increased time were caused by diminished pressure, increased length of tube, or diminished diameter. The specific gravity of the gases seems to have no influence; for carbonic acid, olefant, and oxygen gases, under the same pressure and other equal circumstances, required respectively 4' 6", 3' 3", and 5' 45", for the escape of the same quantity of gas, numbers, as will be seen from the foregoing Table of Specific Gravity of Gases, bearing no proportion to their relative weights. What is singular in these results is, that the ratio for the same gas varies with the pressure, and that this variation differs in different gases. Thus the one

† The specific gravity of this gas, though copied exactly from Berzelius and Dulong, is incorrect. (*Erratum given by Dr. Henry*).—B.

which passes with the greatest facility at low pressures, passes with the least at high pressures.

This investigation has been pursued and extended by M. Girard. (*An. de Chim. et de Phys.* xvi. 129.) He was permitted to use for his experiments the gazometer and pipes belonging to one of the gas lighting establishments at Paris. The gases operated upon were common air, and carburetted hydrogen, which, when allowed to escape at different distances from the gazometer, through equal apertures in a three inch pipe, and under the same pressure, gave the following results:

The distances being	1288,	3758,	6228
The quantities of carb. hyd. were	1281,	710,	541
Ditto of common air	902,	541,	394

The escape of carburetted hydrogen, therefore, considerably exceeded that of common air, but not in proportion to its inferior specific gravity, which is not much more than half that of the atmosphere, while the excess in the escape of the lighter gas is far from being double that of the heavier. Similar results were obtained when the gases were expelled through tubes of 7 lines in diameter, or through an aperture in the side of the gazometer, the lighter gas being discharged in both cases the most abundantly. In the latter case, each gas escaped 11 times faster than when it had to traverse a tube of the same diameter as the hole, and 127 metres in length. In all cases, equal quantities of gas, in any one experiment, escaped in equal times.

These phenomena of the movement of gases through pipes, M. Girard shows, are exactly the same as those of the linear movement of incompressible fluids; and he draws several conclusions, which are important to those practically engaged in operations that require the transmission of gases through long tubes.

Caloric given out during Combustion in Oxygen.—Theory of Combustion.—Vol. I. p. 127.

LAVOISIER has endeavoured to prove (*Elements of Chemistry*, chap. ix.) that a given weight of oxygen abandons very different quantities of heat, when combined with different inflammable bodies. For example, the caloric disengaged from 1 pound of oxygen, during the combustion of its equivalent of phosphorus, he estimates to be sufficient to melt between 66 and 67 pounds of ice; of charcoal, between 37 and 38 pounds; and of hydrogen, 52 pounds of ice. There can be little doubt, that the heat, evolved in these combustions, as well as the light, has its origin partly from the oxygen gas, and partly from the combustible body; but the precise quantity due to each can scarcely be considered as yet determined. Nor must it be understood, that the transition of oxygen from the gaseous to a more dense state is essential to the phenomena of

combustion; for besides that we have several examples of true combustion where oxygen is not at all concerned, as in those effected by chlorine, the principle must now be still more limited by a variety of cases, to be afterwards mentioned, which show that active and vivid combustion is sometimes attended, not with a condensation of the bodies that combine, but on the contrary with a great enlargement of volume; and, what is still more remarkable, that in some instances the new compounds, formed by combustion, have as great a capacity for heat as their constituent principles. (See Petit and Dulong's Memoir. Ann. de Ch. et Phys. x. 395.)

Hydrate of Chlorine:—Exhibition of pure Chlorine and other Gases in a fluid state.—Vol. I. p. 129.

CRYSTALS of hydrate of chlorine are best obtained by introducing into a clean bottle of the gas, a little water, but not enough to convert the whole into hydrate, and then exposing the bottle for a few days to a temperature at or below freezing, in a dark place. A solid compound of chlorine and water is formed, which, in a day or two, sublimates and shoots into delicate prismatic needles, extending from half an inch to two inches into the atmosphere of the bottle. They appear to have a specific gravity rather exceeding 1.2.

When these crystals are put into alcohol, they increase its temperature 8° or 10° ; a rapid action takes place, and much ether and muriatic acid are formed, with a small proportion of a triple compound of chlorine, hydrogen, and carbon. They decompose the solutions of ammoniacal salts, from which they liberate nitrogen gas. At the same time, muriatic acid and chloride of nitrogen are formed.

By precipitating with nitrate of silver a known weight of the crystals, made as dry as possible and then dissolved in water, Mr. Faraday, to whom we owe these interesting facts, obtained proportions of chloride of silver, indicating the crystallized hydrate to consist of

Chlorine	27.7
Water	72.3

100.

This nearly accords with ten atoms of water to one of chlorine, giving, for the equivalent of the hydrate, $90 + 36 = 126$.

A portion of the solid and dried hydrate was put into a small bent tube, which was hermetically sealed. On being heated to 100° , a yellow vapour formed, which condensed in the cool part of the tube into a liquid heavier than water, (sp. gr. probably about 1.3.) On relieving the pressure by breaking the tube, the condensed chlorine instantly assumed the state of gas or vapour.

Sir H. Davy has found also, that muriatic acid gas, generated under similar pressure, becomes an orange-coloured liquid, lighter

than sulphuric acid, and instantly assuming the gaseous form when pressure is removed. Pursuing the same method of experimenting, Mr. Faraday has succeeded in condensing into a liquid state sulphuretted hydrogen, sulphurous acid, carbonic acid, cyanogen, protoxide of chlorine, and nitrous oxide. Other gases, and among them the simple ones, oxygen, hydrogen, and nitrogen, will, it is probable, be found condensible by similar means; all that is wanted being the means of applying sufficient pressure, in an apparatus which shall enable us at the same time to observe the accompanying phenomena. (Quart. Journal, xv. 74, 163.)

Weight and Finite Extent of the Atmosphere, &c.—
Vol. I. p. 133.

THE atmosphere is a collection of elastic fluids, retained on the surface of the earth by their gravitation. Its weight was first ascertained by Galileo, and applied by Toricelli to explain the rise of water in pumps, and of mercury in barometrical tubes; and by Pascal to the mensuration of the height of mountains. At the level of the ocean, it is adequate to sustain a column of water having the altitude of 35 feet; or one of mercury of the height of 30 inches, and it presses with the weight of about 15 pounds on every square inch of surface. As we ascend, the atmosphere decreases in density in a geometrical proportion to equal ascents. Thus at three miles in height, the density of the atmosphere is one-half what it is at the earth's surface, or equal to a column of 15 inches of mercury; at six miles, the barometer would stand at $\frac{1}{2}$ the usual height, or at $7\frac{1}{2}$ inches; at nine miles of elevation, at $5\frac{1}{4}$ inches; and at 15 miles nearly at one inch. Hence the greatest part of the atmosphere is always within 15 or 20 miles of the earth's surface; though, from the refraction of the sun's light, it may be inferred to extend from 40 to 45 miles in height. Beyond the former limit, it appears highly probable, indeed, from the recent observations of Dr. Wollaston, (Phil. Trans. 1822), that our atmosphere does not reach at all; the force of gravity downwards, upon a single particle, being there equal to the resistance arising from the repulsive force of the medium. We have no evidence, then, of the existence of similar matter round any other planet; and, on the contrary, it has been ascertained, by the observations of Captain Kater, that no retardation of the motion of Venus can be perceived in her progress towards the sun, as would happen if the latter were encompassed by a refracting atmosphere. The approach, also, of Jupiter's satellites to the body of that planet is uniformly regular, till they appear in actual contact, showing that there is not that extent of atmosphere, which Jupiter should attract to himself from an infinitely divisible medium filling all space. These observations are favourable, as Dr. Wollaston remarks, to the existence of particles of matter no longer divisible, for if an elastic fluid like our atmosphere consist of such par-

ticles, we can scarcely doubt that all other bodies are similarly constituted; and may without hesitation conclude, that those equivalent quantities, which we have learned to appreciate by proportionate numbers, do really express the relative weights of elementary atoms, the ultimate objects of chemical research.

The great body of air, constituting our atmosphere, is in a state of constant motion, not only from its accompanying the earth in its rotation round its axis, but it flows also from the equator towards the poles, and contrariwise. Over the torrid zones, the air is expanded by heat, and acquires a tendency to ascend, while the air from the temperate and frigid zones presses forward to supply the vacancy. In the torrid zones, the upper regions of the atmosphere meet with less lateral pressure than is necessary to support them, and the air, therefore, overflows in both directions, so that currents northward and southward are established in the higher regions of the atmosphere. Thus a constant circulation is maintained, and a cause established for supporting a temperature on the earth's surface, approaching much more nearly to uniformity, than it could have been without such a provision of nature.

Influence of the Rarefaction and Condensation of Air on the Combustion of Bodies.—Vol I. p. 136.

ATMOSPHERICAL air, when very considerably rarefied, is rendered unfit for supporting combustion. The general fact that flame ceases in air highly rarefied by the air-pump, was well known to the earlier experimenters upon the Boylean vacuum; but the degree of rarefaction, necessary to this effect, has been differently stated. Sir H. Davy (on Flame, p. 57) found, that a jet of inflamed hydrogen from what has been called the philosophical candle, of about one-sixth of an inch in height, when introduced under a receiver, containing from 200 to 300 cubic inches of air, enlarged as the receiver was exhausted by an air-pump. When the gage indicated a pressure between 4 and 5 times less than that of the atmosphere, the flame was at its maximum size; it then gradually diminished below, but burned above, till the pressure was between 7 and 8 times less. Using a larger jet with the same apparatus, it burned till the pressure was reduced to one-tenth that of the atmosphere; and when a coil of platinum wire was kept in the flame in a state of ignition, the combustion did not cease till the pressure was reduced 13 times. The combustibility of hydrogen in atmospheric air does not, therefore, appear to be increased or diminished by mere rarefaction from the removal of pressure, but to cease in rarefied atmospheres, only when the heat produced is insufficient to keep up the combustion, or at that point when it is incapable of communicating visible ignition to metal.

It is not, however, by the same degree of rarefaction of air, that the combustion of all bodies is suspended; for, as might naturally be expected, those which require least heat for their combustion,

burn in more rarefied air than those that require a higher temperature; and again, those that produce much heat in their combustion, burn in more rarefied air than those which evolve little heat. The following table, collected from Sir H. Davy's experiments, shows the degrees of rarefaction of common air, at which the combustion of some inflammable bodies ceases, both with and without the appendage of a coil of platinum wire.

	Without Platinum.	With Platinum.
Olefiant gas ceases to burn in air } "rarefied }	11 to 12 times.
Carburetted hydrogen	4 . . .
Carbonic oxide	6 . . .
Alcohol } Wax tapers }	5 to 6	7 to 8
Sulphuretted hydrogen 7
Sulphur	15 to 20
Phosphorus	60

By preserving heat in rarefied air, Sir H. Davy found that the inflammation of bodies may be continued, when, under other circumstances, it would have been extinguished. Thus, when camphor was burned in a glass tube, so as to make the upper part of the tube red-hot, the inflammation continued when the rarefaction was 9 times; whereas it would only continue in air rarefied 6 times, when the camphor was burned in a thick metallic tube, which could not be considerably heated by it. By other experiments, he has shown, also, that expansion by heat, instead of diminishing the combustibility of gases, enables them, on the contrary, to explode at a lower temperature.

The power of atmospheric air to support combustion is diminished also by mixing it with some other gases. Thus, Sir H. Davy found, that a candle is instantly extinguished in air mixed with one-tenth of silicated fluoric acid gas, or with one-sixth of muriatic acid gas. But air, thus rendered inadequate to support the combustion of one sort of inflammable substance, is capable of maintaining that of others, as is proved in an elegant manner by the following experiment of the same philosopher. Into a long bottle with a narrow neck introduce a lighted taper, and let it burn till it is extinguished. Carefully stop the bottle, and introduce another lighted taper; it will be extinguished before it reaches the bottom of the neck; then introduce a small tube containing zinc and diluted sulphuric acid, at the mouth of which the hydrogen is inflamed; the hydrogen will be found to burn, in whatever part of the vessel it is placed. After the hydrogen is extinguished, introduce lighted sulphur; this will burn for some time; and, after its extinction, phosphorus will be as luminous as in the open air, and, if heated in the bottle, will produce a pale yellow flame of considerable density. (*Davy on Flame*, p. 82.)

The mechanical condensation of air does not adapt it for supporting a more vivid combustion. Sir H. Davy's experiments are

the only ones we possess on this subject. He condensed air nearly five times, and then ignited iron wire to whiteness in it, by the Voltaic apparatus, but the combustion took place with very little more brightness than in the common atmosphere, and would not continue as in oxygen; nor did charcoal burn much more brightly in this compressed air than in common air.

Weight and Composition of Atmospheric Air.—Vol. I. p. 137.

Mr. Brande (Manual, i. 379) deduces from twelve experiments, made at the Royal Institution with great care and an excellent balance, that 100 cubic inches of air, at a mean of the barometer and thermometer, weigh only 30.199 grains. On the whole, perhaps, 30.5 grains may be considered as a near approximation.

All eudiometrical processes, when skilfully performed, concur to prove, that, apart from the carbonic acid and aqueous vapour which are present in atmospheric air, 100 volumes consist of 79 oxygen, and 21 nitrogen; or, including the two former ingredients, that it is constituted, at a mean temperature and pressure, of

Nitrogen gas . . .	77.5	by measure.	75.55	by weight.
Oxygen gas . . .	21.		23.32	
Aqueous vapour . .	1.42		1.03	
Carbonic acid . . .	0.08		0.10	
	<hr/>		<hr/>	
	100.00		100.00	

It is remarkable, also, that, with the exception of the aqueous vapour, the quantity of which varies with the temperature, as will presently appear, the other ingredients of the atmosphere bear at all times, in all quarters of the globe, and at all accessible heights above its surface, the same relative proportion to each other. Thus air from the Alps analyzed by Saussure, Jun., from Spain by De Marti, from France and Egypt by Berthollet, from England and the coast of Guinea by Davy, from the Peak of Teneriffe and from near the summit of the Andes by Humboldt, and from the height of nearly 22,000 feet by Gay-Lussac and Thenard, all gave results approaching as nearly as possible to each other. The unknown ingredients which are occasionally mingled with the atmosphere, and which impart to it deleterious properties, are either of too subtile a nature, or present in too small a proportion, to be discoverable by our imperfect instruments.

Two views have been taken of the nature of the union, which exists among the several elastic fluids constituting the atmosphere. By the greater part of chemists, it has been considered as a chemical compound, chiefly from the uniformity of its composition, and from the fact that its several ingredients do not separate and arrange themselves according to their respective specific gravities. Mr. Dalton was the first who presented, under a distinct view, the theory, that, of the various elastic fluids constituting

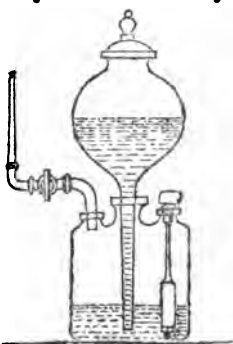
the atmosphere, the particles of one have neither attractive nor repulsive power towards those of another; but that the weight or pressure, upon any one particle of any fluid mixture of this sort, arises solely from the particles of its own kind. According to this hypothesis, oxygen, azotic, and carbonic acid gases (or indeed any number) may exist together under any pressure, and at any temperature, while each of them, however paradoxical it may appear, occupies the whole space allotted for all. Each ingredient of the atmosphere, on this view, exerts its own separate pressure in supporting the mercury of the barometer, and performs the part assigned to it in the following table.

	Inch. of Mercury.
The nitrogen gas exerts a pressure	= 23.36
Oxygen gas	= 6.18
Aqueous vapour	= 0.44
Carbonic acid gas	= 0.02
	<hr/> 50.00

To enter fully into the arguments for and against this doctrine, would lead into discussions of too great length for an elementary work; and I shall only, therefore, express my opinion, that on the whole it is more probable, and encumbered with fewer difficulties, than the theory that the constituents of the atmosphere are held united by chemical affinity. It must be acknowledged, as has been done by Mr. Dalton, that taking the azotic part of the atmosphere as a standard, the oxygen and carbonic acid must observe a decreasing ratio to it in ascending, and the aqueous vapour an increasing one. But on the summit of Mont Blanc, (nearly three English miles in perpendicular height), the ratio of the oxygen to the nitrogen would still be very nearly as 20 to 80, and at all ordinary heights, the difference of proportions must be scarcely appreciable.

Gay-Lussac's Apparatus for obtaining Hydrogen.—Vol. I. p. 128.

THE annexed cut shows the construction of Gay-Lussac's apparatus for obtaining hydrogen instantaneously in a laboratory. It consists of a three-necked glass bottle, one of whose openings has a stopper, from which is suspended a small cylinder of zinc. To the opposite aperture is fixed a bent brass tube furnished with a stop-cock, on which may be screwed either a small jet for burning the gas, or a tube to conduct it wherever it may be required. The upper vessel is of glass, and ground to fit the middle neck, its pipe reaching within a small distance of the bottom of the bottle. To use the apparatus, the lower vessel is filled with sulphuric acid properly diluted, and the zinc cylinder is then introduced, the stopper be-



ing closed to which it is affixed, and the cover of the upper vessel removed. The gas, which is generated, drives the diluted acid into the upper vessel, and the further production of it ceases, when the zinc is completely uncovered. We have then the bottle filled with gas; and can at any time expel it by opening the cock, and allowing the atmosphere to press on the surface of the liquid in the globular vessel.

Explosion of a Mixture of Oxygen and Hydrogen Gases in a Rarefied State.—Vol. I. p. 140.

OXYGEN and hydrogen gases, in the proportions to form water, it is admitted by Sir H. Davy, will not explode by the electric spark when mechanically rarefied 18 times; but when the tube containing the expanded gases was artificially heated so as nearly to soften, and the electric spark then passed, a feeble flash of light was visible, which is not consistent with the last mentioned experiments of Grothius. Sir H. Davy found, also, that dilatation by heat, instead of diminishing the explosiveness of a mixture of hydrogen and oxygen gases in the proportions that saturate each other, on the contrary enabled them to explode at lower temperatures. Thus a mixture of two volumes of hydrogen and one of oxygen, being expanded by a spirit lamp to $2\frac{1}{2}$ volumes, instantly exploded when the upper part of the tube containing it, was made red-hot by another spirit lamp. He even found that a heat much below redness (somewhere between the boiling point of mercury, and the greatest heat that can be given short of rendering glass luminous in the dark) occasions a mixture of hydrogen and oxygen gases to unite without violence or evolution of light; but that if, to a mixture so circumstanced, a red heat be suddenly applied, an explosion always takes place. (On Flame, p. 68.)

A glowing coal, if red in day light, and free from ashes, uniformly explodes a mixture of hydrogen and oxygen gases; but if its redness is barely visible in the shade, it will not explode them, but will cause their slow combination. This is not owing to rarefaction; for if an iron wire heated to whiteness be placed upon the coal within the vessel, the mixture instantly detonates.

Specific Gravity of Hydrogen.—Vol. I. p. 144.

DR. THOMSON, by recent experiments, (Ann. Phil. xvi. 168), reduces the sp. gr. of hydrogen to 0.06940, which is precisely the number deduced by Dr. Prout from the composition and specific gravity of ammonia. It does not appear, however, that Dr. Thomson operated on the gas artificially dried, and the aqueous vapour diffused through his gas would a little increase its specific gravity. Berzelius and Dulong, having taken the precaution to dry their hydrogen gas, found its specific gravity to be only 0.0688, from whence, taking 100 cubic inches of atmospheric air

at 31 grains, we find 100 cubic inches of dry hydrogen gas, at a mean of the barometer and thermometer, to weigh 2.13 grains. (Ann. de Chim. et Phys. xv. 393.)

ADDITIONS TO THE CHAPTER ON THE COMPOSITION,
DECOMPOSITION, AND PROPERTIES OF WATER.

PART I. CHAP. VI.

Composition of Water.—Vol. I. p. 148.

THE most recent experiments, on the specific gravities of oxygen and hydrogen gases, lead to an alteration in the statement of the composition of water, as heretofore determined by its synthesis. According to the results of Dr. Thomson, oxygen gas is precisely 16 times heavier than hydrogen gas, and according to Berzelius and Dulong, a little more than 16 times; but if we take 16 to 1 as the nearest approximation, it will follow, since water consists of two volumes of hydrogen and one of oxygen, that eight parts by weight of oxygen and one of hydrogen constitute water, or, according to the last mentioned chemists, it consists of

Oxygen	88.9
Hydrogen	11.1
	<hr/>
	100.

State in which Water exists in the Atmosphere.—Vol. I. p. 153.

THE opinion of Mr. Dalton, that the water existing in atmospheric air, constitutes a distinct and independent atmosphere, steers clear of the inconsistency, attending the supposition, that the aqueous particles, contained in it at ordinary temperatures, are in a different state from that existing in a Toricellian vacuum; and again, that water below 212° Fahr. is chemically combined with the atmosphere, and above 212° assumes a new form, and becomes a distinct elastic fluid called *steam*. It is certainly much more reasonable to suppose, that water, whenever it exists as an elastic fluid, whether distinct from or mixed with others, is maintained as such, by one and the same cause, *viz.* the caloric which enters into it; and not by chemical solution in any gas or mixture of gases.

It may be asked, indeed, why the diffusion of vapour in the atmosphere is not instantaneous as it is *in vacuo*? This appears to be owing to the *vis inertiae* of the particles of air, and the resistance is probably similar to that which a stream of water meets in descending through a bed of pebbles. The evaporation of water, we find, is accelerated either by raising its temperature, by increasing its surface, or by causing a current of air to pass over it. In the first case, the force of the vapour, or its power of overcoming obstacles, is increased; and the quantity of water evaporated in a given time bears, as Mr. Dalton found, a proportion to the force of vapour of the same temperature: Thus the forces of vapour at 212° , 180° , 164° , 152° , 144° , and 138° are equal to 30, 15, 10, $7\frac{1}{2}$, 6, and 5 inches of mercury respectively, and the grains of water evaporated *per minute* in those temperatures were 30, 15, 10, 7, 6, and 5 also, or numbers proportional to these. The evaporation from a vessel containing water at 212° in a still atmosphere, Mr. Dalton found, was increased one-half by a current, and a still stronger current, he thinks it probable, would have doubled it. In this case, the removal of a mechanical obstacle conspires with the force of the vapour; and as steam rises only from the surface of water, it is obvious that increase of surface must quicken evaporation by augmenting the quantity of vapour of a given force. Another circumstance, influencing the rate of evaporation, is the force of the vapour actually existing in the atmosphere at the time; for the less this force, or in other words the less the quantity of vapour in the air, the more rapid is the evaporation from a given surface of water of a given temperature. Hence an increase of temperature in the air quickens evaporation by enabling the atmosphere to hold steam of greater force; and by a current of heated air, we apply two causes conjointly, both of which tend to quicken evaporation.

The method of finding the force of vapour in the atmosphere, employed by Mr. Dalton, is extremely simple and elegant. A glass jar, or a common tumbler (the thinner the glass the better) may be filled with cold spring water fresh from the well. If dew be immediately formed on the outside, the water is poured out and allowed to stand awhile to increase in heat; the glass is then well dried with a linen cloth, and the water poured in again. This operation is continued till dew ceases to be formed, and then the temperature of the water is to be observed, and opposite to it in the Table (see Tables at the end of this Supplement) will be found the force of vapour in the atmosphere. This must be done either in the air or at an open window; because the air within is generally more humid than that without. Spring water in this country is commonly about 50° Fahr., and will mostly answer the purpose during the three hottest months of the year: in other seasons, artificial cold, produced by dissolving a little of any fit neutral salt in the water, is required.

In the torrid zone, the aqueous atmosphere is equal to a pressure of six-tenths of an inch of mercury, and increases even to

one inch. In this climate, Mr. Dalton has observed it above half an inch in summer; but in winter it is sometimes so low as one-tenth, or even half a tenth; and at the same place, and during the same season, it is constantly varying with the temperature of the air. It is easy then to see, at any time, what proportion it constitutes of the whole weight of the atmosphere by taking the *dew point*; observing the barometer at the time when the experiment is made; and referring to Mr. Dalton's Table of the Force of Vapour.

Deutoxide or Peroxide of Hydrogen.—Vol. I. p. 157.

ONLY one compound of hydrogen and oxygen, namely water, was known until, in July 1818, M. Thenard discovered, that, by a process somewhat difficult and complicated, an additional dose of oxygen may be communicated to that fluid; and a compound obtained, which is possessed of a new and very remarkable train of properties.

To obtain this product, it is necessary to employ the peroxide of barium. This compound, when acted upon by liquid hydrochloric (muriatic) acid, abandons part of its oxygen, and is reduced to the state of protoxide, (baryta), which unites with the muriatic acid, while the oxygen unites with the water. Sulphuric acid, added to the compound fluid, carries down the baryta, and sets muriatic acid at liberty, which is ready to act upon a fresh quantity of the peroxide of barium. This operation may be several times repeated, and at each repetition the water becomes charged with an additional quantity of oxygen. When the process has been carried far enough, sulphate of silver is added, to precipitate the free muriatic acid, which it replaces by a quantity of free sulphuric acid; but the latter is easily separated by adding a due proportion of baryta. This is a general outline of the process, to insure the perfect success of which seems to require many precautions, and especially the greatest attention to the purity of the peroxide of barium.

The peroxide of hydrogen is liquid and colourless like water. It has scarcely any smell, but when applied to the tongue whitens it, thickens the saliva and produces a taste like that of some strong metallic solutions. It attacks the skin with great rapidity, bleaches it, and occasions a smarting, the duration of which differs in different persons, and in the same person according to the quantity applied. Its specific gravity is 1.452, and when poured into water it descends through it like sirup, though easily dissolved by agitation. Its tendency to the vaporous form is much less than that of water, and hence, when very dilute, it may be concentrated by exposing it under the receiver of an air-pump, along with any strongly deliquescent substance. If continued long in this situation, however, it at length disappears. In its most concentrated form, it has not been congealed by any degree of artificial cold yet applied to it.

When once prepared, it is necessary to keep it surrounded by ice, for a temperature of 58° Fahr. is sufficient to decompose it, and to liberate oxygen gas in great abundance. The action of heat varies with its degree of concentration. Seven or eight grains of the sp. gr. 1.452 are sufficient to occasion a violent explosion; and therefore to obtain safely the whole of its excess of oxygen above that constituting water, it is necessary, before applying heat, to dilute it with about 20 parts by weight of water. By experiments of this kind, carefully made, M. Thenard ascertained, that, admitting water to be composed of 11.71 hydrogen and 88.29 oxygen, this new compound contains exactly double that quantity of oxygen, or 11.71 hydrogen, and 176.58 oxygen, or

Hydrogen	1
Oxygen	16

If water then be a compound of one atom of hydrogen and one of oxygen, the peroxide must consist of one atom of hydrogen and two of oxygen, and its representative number (hydrogen being unity) will be 17, or oxygen being 10, it will be 21.250.

Light does not exert any speedy operation on the peroxide of hydrogen. Of the metals, tin, iron, antimony, and tellurium, bring it back rapidly to the state of water. Some metals, as silver, platina, gold, &c., when finely divided and added to it, liberate its oxygen, without themselves undergoing any change, in a way which is not easily explained. Others (arsenic, molybdena, tungsten, potassium, sodium, &c.) liberate one part of the oxygen and absorb the rest. Acids render it a more stable compound. For example, when to diluted peroxide of hydrogen, effervescing from the application of an increased temperature, we add phosphoric, sulphuric, muriatic, arsenic, acetic, tartaric, citric, or oxalic acid, the discharge of gas is suspended. Carbonic and boracic acids do not produce this effect, on account probably of their feeble powers as acids. Sulphurous and hydriodic acids, and sulphuretted hydrogen decompose the peroxide, and possess themselves of its oxygen.

The following substances, when added to the concentrated peroxide, occasion explosions of greater or less violence; oxide of silver, peroxide of lead, peroxide of manganese artificially prepared, osmium, silver, and platina, the two last in the finest state of division in which they can be obtained by chemical precipitation.

ADDITIONS TO THE CHAPTER ON THE CHEMICAL AGENCIES OF COMMON AND GALVANIC ELECTRICITY.

PART I. CHAP. VII.

Galvanic Deflagrator of Dr. Hare.—Vol. I. p. 162.

A CONVENIENT and powerful galvanic battery has been constructed by Dr. Hare of Philadelphia, of zinc and copper sheets formed into coils. The zinc sheets were about nine inches by six; the copper, fourteen by six; more of the latter metal being necessary, as, in every coil, it was made to commence within the zinc, and completely to surround it without. The sheets were coiled so as not to leave between them an interstice wider than a quarter of an inch. Each coil was in diameter about two inches and a half; their number amounted to 80; and, by means of a lever, they were made all to descend together into 80 glass jars, 2 inches and 3-4ths diameter inside, and eight inches high, duly placed to receive them. The effects of this apparatus, in producing ignition, appear to have been very striking, especially at the moment of immersion, when Dr. Hare found the effect to be by much the most powerful. An apparatus of 80 coils produced a vivid ignition in charcoal; and when the points of the charcoal were drawn three-fourths of an inch apart from each other, a most brilliant arc of flame extended between them.

Electro-Magnetic Phenomena.—Vol. I. p. 177.

ALL the effects of galvanic arrangements, that have hitherto been described, are produced in bodies when interposed between the extremities of conductors proceeding from the positive and negative poles; in other words, so placed that the galvanic current is imperfectly continued through the body intended to be acted upon. It was not known that the electric current, passing *uninterruptedly* through a wire connecting the two ends of a galvanic battery, is capable of being manifested by any effect, till Professor Oersted, of Copenhagen, in the winter of 1819, discovered an unequivocal test of its passage in its effect on the magnetic needle. The opposite poles of a battery of sufficient magnitude, in full action, were joined by a metallic wire, which, for shortness, he calls the *uniting conductor*, or *uniting wire*. This wire was either placed horizontally, or bent in any other direction required by the nature of the experiment. When the wire was placed horizontally over, and parallel to a magnetic needle properly suspended, and

at a distance not exceeding three quarters of an inch, the needle was moved, and the end of it next to the negative pole of the battery turned westwards. The circumstances of the experiment remaining in every respect the same, except that the uniting wire was placed *under* the needle instead of over it, the declination of the needle was in an opposite direction; for the pole next the negative end of the battery now turned eastwards. Again, when the connecting wire and needle were situated in the same horizontal plane, no declination took place, either to the east or west, but an *inclination*, or vertical dip of the needle was observed. When the uniting wire was west of the needle, the pole next to the negative end of the battery was depressed; when the wire was to the east, the same pole was elevated.

When the uniting wire was situated perpendicularly to the plane of the magnetic meridian, the needle, whether above or below the wire, remained at rest, unless the pole were very near the wire. In that case, the pole was *elevated*, if the negative electricity entered from the west side; and *depressed*, if from the east. M. Von Buch has since, however, shown that this state of rest does not continue in two of the four positions of the wire, provided a sufficient galvanic power be employed in the experiment. (Ann. of Phil. N. S. ii. 285.)

When the uniting wire was perpendicularly opposite to the north pole of the suspended needle, and the upper extremity of the wire connected with the *negative* end of the battery, the pole, when brought near the wire, moved towards the east. But when the wire was opposite to a point between the pole and the middle of the needle, the pole moved westwards. When the upper end of the wire was made to receive *positive* electricity, the phenomena were reversed.

The amount of these effects diminished with the decreasing power of the battery, and with the distance of the needle from the uniting wire. This wire, it was found, may consist of almost any metal; nor does it lose its effect though interrupted by a column of water, provided the column does not extend to several inches in length. It is remarkable, also, contrary to what is observed in any other effect of electricity or galvanism, that the influence of the uniting wire passes to the needle through plates of glass, metal, or wood, the disc of an electrophorus, or a stone-ware vessel of water; nor does the sudden interposition of any of these bodies destroy or sensibly diminish the effect. On needles of brass, glass, or gum lac, no effect whatever is produced.

The common electrometer indicates the tension or intensity of electricity; but, till the discovery of M. Oersted, we had no instrument to show the direction of its current. The effect on the needle depends, indeed, entirely on the current. So long as this current is interrupted, no effect is produced on the needle; but the moment it is restored, the north pole of the needle is turned to the left of the observer, supposing him to have his face directed towards that pole. This may be more briefly expressed by saying,

that the north pole is carried to the left of the current which acts upon the needle. We thus acquire a *galvanometer*, capable of pointing out the direction of the electric current under all circumstances.

By an instrument nicely constructed on this principle, M. Ampère ascertained, that the current in the voltaic battery itself, from the negative to the positive extremity, has the same influence on the needle, as that current, which, in the uniting wire, goes on the contrary from the positive to the negative pole. This is best shown by two needles, the one placed upon the pile, the other above or under the conductor. In each, the north pole of the needle will be seen turned to the left of the current near which it is placed; the two needles are both carried to the same side, and are nearly parallel, when one is above the pile, and the other beneath the conductor.

When two rectilinear portions of two conducting wires, joining the extremities of two voltaic piles, are so disposed, that the one is fixed and the other suspended so as to be moveable; the latter will approach the former if the currents be in the same sense, and will be repelled when the currents are in opposite directions. In common electrical attractions and repulsions, electricities of the same name are mutually repulsive, and opposite electricities attract each other. But in the attractions and repulsions of electric currents, it is precisely the reverse; the repulsion taking place only when the wires are so situated that the currents are in opposite directions. The attractions and repulsions of these currents, unlike the mutual action of bodies electrized in the common way, takes place equally *in vacuo* as in air.

The discovery of M. Oersted was limited to the action of the electric current on needles previously magnetized. But it was afterwards, and about the same time, ascertained both by Sir H. Davy and M. Arago, that magnetism may be developed, in steel not previously possessing it, by being placed in the electric current, and may even be excited in the uniting wire itself. Both philosophers ascertained, independently of each other, that the uniting wire, becoming a magnet, attracts iron filings, and collects sufficient to acquire the diameter of a common quill. The moment the connexion is broken, all the filings drop off;* and the attraction diminishes also with the decaying energy of the pile. Filings of brass or copper, or wood shavings, are not attracted at all.

The communication of magnetic properties to a steel needle was effected, by Sir H. Davy and M. Arago, in different ways. The former observed that steel needles, placed upon the connecting wire, became magnetic; those parallel to the wire acted like the wire itself; those placed across it each acquired two poles. Such as were placed *under* the wire, the positive end of the battery being east, had north poles on the south of the wire, and south

* M. Arago afterwards determined that the wire retains its magnetism for a few instants after the connexion is broken, but that it soon ceases.

poles to the north. The needles *above* were in the opposite direction, and this was constantly the case. whatever might be the inclination of the needle to the wire. On breaking the connexion, the steel needles, placed *across* the uniting wire, retained their magnetism, while those placed *parallel* to it lost it at the moment of disunion. Contact with the uniting wire was not found necessary; for the effect was produced though thick glass intervened. Increasing the size of the plates of the battery increased the magnetic effect of the connecting wires; thus the wire uniting the poles of a battery of 60 pairs of plates did not take up half so much filings, as when the battery was arranged so as to form 30 pairs of twice the size.

Similar effects were produced in Sir H. Davy's experiments by the electricity excited by a common machine. A battery of 17 square feet, discharged through a silver wire $\frac{1}{16}$ th of an inch diameter, rendered bars of steel, two inches long and from $\frac{1}{16}$ th to $\frac{1}{8}$ th thick, so magnetic as to lift up pieces of steel wire and needles; and the effect was communicated to needles at the distance of five inches from the wire, even with the intervention of water or of thick plates of glass or metal. Various other important facts respecting the communication of magnetism are described in the paper of the same author, published in the Philosophical Transactions for 1821, all tending to establish the conclusion, that magnetism is produced whenever concentrated electricity is passed through space.

On the suggestion of M. Ampère, M. Arago communicated magnetism to the needle in a different manner. A copper wire, by being rolled round a solid rod, was twisted into a spiral so as to form a *helix*. It was easy, by passing the wire round the rod, in one direction or the other, to form a *dextrorsal* helix, proceeding from the right hand towards the left, as in the tendrils of many plants; or a *sinistrorsal*, or left helix, proceeding downwards from the left hand to the right above the axis. Into the cavity of a spiral thus formed, connecting the two poles of a battery, a steel needle wrapped in paper was introduced; and in order to exclude all influence of the magnetism of the earth, the conchoidal part of the wire was kept constantly perpendicular to the magnetic meridian. In a few minutes the needle had acquired a sufficiently strong dose of magnetism; and the position of the north and south poles exactly agreed with Mr. Ampère's notion, that the electric current traverses the connecting wire in a direction from the zinc extremity of the pile to the copper extremity.

In another experiment, using one copper wire, two symmetrical spirals were formed, each nearly two inches long, and separated by a rectilinear piece of the same metal, the spirals of the two being turned in contrary senses. Within each of these spirals, a needle, properly guarded, was included, and the connexion made between the two ends of a galvanic battery. The result was, that both the needles were magnetized, but in exactly opposite senses. When a right helix had been used, that end of the needle, which

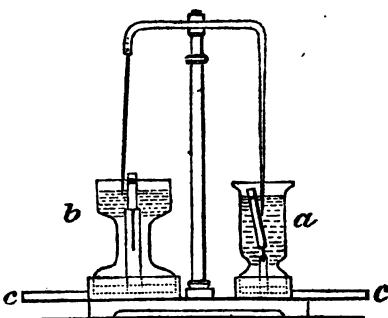
had been placed towards the negative pole of the battery, pointed to the north, and the other end to the south; but with a left helix, that end of the needle which had been nearest the positive pole of the battery pointed north, and the other end south. In one case, when the connecting wire had been twisted into three consecutive helices, the middle one being different from the other two, a single piece of steel wire, sufficiently long to pass through all three, being inclosed in a glass tube, was placed within them. On being removed, it was found to have acquired six poles: first a north pole, a little further on a south pole, then another south pole, a north pole, another north pole, and at the further end a south pole.

The electricity of a common machine, it was afterwards ascertained by the Chev. Yelin, when passed along a helix, either in simple electrical sparks, or discharges from a battery, has the effect of rendering an included needle magnetic. In varying these experiments, M. Bockman ascertained that no modification of the effect was produced by altering the diameter of the helix from half an inch to 13 inches. With a helix of 34 inches diameter, and a coated surface of 300 square inches, much less magnetism was, however, imparted; and with one of 84 inches, it was scarcely perceptible. It was found that a needle outside of the helix was magnetized as much as one within; that after being once fully magnetized, a continuation of the discharges diminished its power; and that five jars, each of 300 square inches, did not produce, by repeated discharges, much more effect than one of them.

Any wire, through which a current of electricity is passing, has a tendency to revolve round a magnetic pole, in a plane perpendicular to the current; and that without any reference to the axis of the magnet, the pole of which is used. Also a magnetic pole has a tendency to revolve round such a wire.

Suppose the wire perpendicular, its upper end positive, or attached to the positive pole of a voltaic battery, and its lower end negative; and let the centre of a watch dial represent the magnetic pole: if it be a north pole, the wire will rotate round it in the direction that the watch hands move; if it be a south pole, the motion will be in the opposite direction. From these two, the motions which would take place if the wire were inverted, or the pole changed or made to move, may be readily ascertained, since the relation now pointed out remains constant.

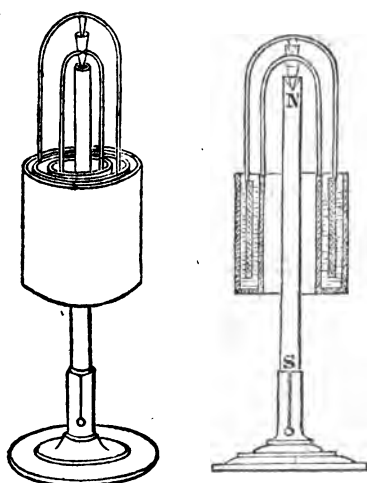
The apparatus in the sketch is the ingenious invention of Mr. Faraday, and is intended to illustrate these motions. The central pillar supports a piece of thick copper wire, which, on the one side, dips into the mercury contained in a small glass cup, *a*. To a pin at the bottom of this cup a small cylindrical magnet is attached by a piece of thread, *c*



so that one pole shall rise a little above the surface of the mercury, and be at liberty to move round the wire. The bottom of the cup is perforated, and has a copper pin passing through it, which, touching the mercury in the inside, is also in contact with the wire that proceeds outwards on that side the instrument. On the other side of the instrument *b*, the thick copper wire, soon after turning down, terminates, but a thinner piece of wire forms a communication between it and the mercury in the cup beneath. As freedom of motion is required in this wire, it is made to communicate with the former by a ball and socket joint, the ball being held in the socket by a piece of thread; or else the ends are bent into hooks, and the one then hooked on to the other. As good metallic contact is required, the parts should be amalgamated, and a small drop of mercury placed between them, and the lower ends of the wire should also be amalgamated. Beneath the hanging wire a small circular magnet is fixed in the socket of the cup, *b*, so that one of its poles is a little above the mercury. As in the former cup, a metallic connexion is made through the bottom from the mercury to the external wire.

If now the poles of a battery be connected with the horizontal external wires *cc*, the current of electricity will be through the mercury and the horizontal wire on the pillar which connects them, and it will now be found, that the moveable part of the wire will rotate round the magnetic pole in the one cup, *b*, and the magnetic pole round the fixed wire in the other cup, *a*, in the direction before mentioned.

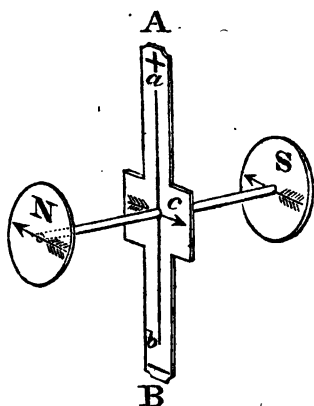
By using a delicate apparatus, the magnetic pole of the earth may be made to put the wire in motion. The rotation then takes place round a line parallel to the dipping needle: hence the rotating wire must always be inclined, so that the solid it describes in revolving, if a cone, and not a mere circle, should include a line parallel to the dip which passes through its apex.



Another ingenious contrivance for illustrating the rotatory motion of the wire round the pole of a magnet has been invented by M. Ampère, and has the advantage of comprising within itself the voltaic combination which is employed. It consists of a cylinder of copper about 2 inches high, and $1\frac{1}{4}$ inch internal diameter, within which is a smaller cylinder about 1 inch diameter. (See the wood cut.) The two cylinders are fixed together by a bottom, having a hole in its centre the size of the smaller cylinder, leaving a circular cell which may be filled with acid. A piece of strong copper wire is fastened across the top of the inner cylinder, and from the middle of it rises at a right angle a piece of copper wire, supporting a very small metal cup containing a few globules of mercury. A cylinder of zinc, open at each end, and about $1\frac{1}{4}$ inch diameter, completes the voltaic combination. To the latter cylinder a wire, bent like an inverted U, is soldered at opposite sides; and in the bend of this wire a metallic point is fixed, which, when fixed in the little cup of mercury, suspends the zinc cylinder in the cell, and allows it a free circular motion. On the suggestion of Mr. Barlow, Mr. Newman has lately fixed an additional point directed downwards from the central part of the stronger wire, which point is adapted to a small hole at the top of a bar magnet. When the apparatus with one point only is charged with diluted acid, and set on the end of a magnet placed vertically, the zinc cylinder revolves in a direction determined by the magnetic pole which is uppermost. With two points, the copper revolves in one direction, and the zinc in a contrary one. The magnet employed should be a powerful one.

As it is not easy always to bear in mind the direction in which the different poles of a magnet tend to revolve round the galvanised wire, or in which the wire tends to revolve round each respective magnetic pole, the following contrivance, invented by Dr. Roget,

which he has been so good as to communicate to me, will be found very useful in aiding our conceptions, while studying the circumstances of an experiment, or anticipating the result of any new combination. AB. (see the wood cut) is a slip of card, on each side of which a line $a\ b$ is drawn along the middle of its length, the end a being marked +, the end b —, and the centre c being crossed by an arrow at right angles to it, directed as in the figure. Through the centre and at right angles to the plane of the slip of card, there is made to pass a slender stem of wood, at the two ends of which are fixed, in planes parallel to the slip of card AB, the circular discs of card, marked respectively with the letters N and S, and with arrows parallel to, but pointing in a contrary direction to the one at c . The same marks must be put on the reverse of each of the three pieces of card, so that when held in different situations they may be seen without turning the instrument.



If the line $a\ b$ be supposed to represent the galvanic wire, (the direction of the current of electricity being denoted by the signs + and —, at the ends of the line), the arrow at the centre will point out the direction in which it tends to move, when under the influence of the north pole of a magnet situated at N; or of a south pole situated on the other side at S: and, *vice versa*, the arrows at N and S will indicate the directions in which the north and south pole, respectively, tends to revolve round the galvanised wire in its vicinity, with relation to the direction of the current of electricity that is passing through it.

It must be observed that the poles N and S are here not considered as in connexion with each other, or as forming parts of one magnet: their operations are exhibited singly, and quite independently of each other. The advantage of this little instrument consists in its being capable of being held in any situation, and thus easily adapted to the circumstances of any fact or experiment, of which we may wish to examine the theory.

The above is but a very imperfect outline of the important facts already known respecting electro-magnetism; but it would lead me into details too extensive to go farther into the subject. I refer, therefore, to the original memoirs of Oersted, Arago, Ampère, Sir H. Davy, Faraday, and others; and those who wish only for a general view of the subject, will find it in an "Historical Sketch of Electro-magnetism," published in the 2d and 3d volumes, N. S. of the Annals of Philosophy. It is necessary, however, before dismissing the subject, to offer a brief view of the explanation which has been given of the leading phenomena.

The theory of Oersted, which, though it appears to have led him to his principal discoveries, is not stated in a very intelligible manner, rests on the assumption of two different and opposite electricities, positive and negative, the former of which is developed by the more oxidizable, the latter by the less oxidizable metal of galvanic arrangements. Each of these forces has a repulsive activity for itself, and an attractive activity for the opposite force. In the wire connecting the two opposite poles of a galvanic battery, and in the space around it, there are, he supposes, two currents, the one of positive, the other of negative electricity, moving in spiral and opposite directions; and an effect is supposed to take place in the wire and around it, dependent on the union of these electricities, to which he gives the name of the *electric conflict*. By this conflict, all non-magnetic bodies appear to be penetrable, while magnetic bodies, or rather their magnetic particles, resist its passage, and are, therefore, moved by the impetus of the contending powers. All the effects on the north pole of the needle may be understood by supposing that negative electricity moves in a spiral line bent to the right, propelling the north pole, but not acting on the south pole. To positive electricity, a contrary motion is ascribed, and a power of acting on the south pole, but not on the north. This theory requires, therefore, that there be two electric fluids: but in the opinion of Dr. Wollaston, which on every obscure topic of science is entitled to the greatest deference, the phenomena may be equally well explained by a single electro-magnetic current, passing round the axis of the wire, in a direction determined by the position of the voltaic poles. The assumption of such a current is, it must be confessed, altogether gratuitous; but, without such a supposition, it is not easy to conceive any adequate cause for the motions that are observed in the magnetic needle, when brought within the influence of the uniting wires. Further researches will probably unfold the causes of these interesting phenomena, and class them under general laws, founded on a more extensive induction of facts than we now possess, notwithstanding the zeal and genius that have already been devoted to the inquiry.

ADDITIONS TO THE CHAPTER ON THE ALKALIES,
PART I. CHAP. VIII.

Potassium with Sulphur.—Vol. I. p. 188.

WHEN sulphate of potassa is decomposed by hydrogen gas or by charcoal at a red heat, the residue is a compound of sulphur and potassium. It is difficult to obtain it perfectly pure, for it acts

both on glass and on platinum. When prepared in glass, it has a pale cinnabar colour, and a crystalline fracture; fuses at a heat below redness; and then becomes dark and opaque. It attracts moisture from the air; and dissolves into a yellowish fluid, which, when diluted with water, becomes colourless. This appears to be a sulphuret of the first degree of sulphuration.

By fusing sub-carbonate of potassa with double its weight of sulphur, out of the contact of air, a sulphuret of potassium is formed, in which 100 of the metal are united with 207.7 of sulphur, which is equivalent to 10 atoms. Varying the proportions, Berzelius, to whom we owe these facts, obtained sulphurets which he regards as compounds of 1 atom of potassium with 2, 4, 6, 7, 8, 9, and 10 atoms of sulphur.

Extraction of Lithia from Petalite.—Vol. I. p. 194.

M. ARFVEDSON decomposed petalite by the following method. He strongly calcined, for an hour and a half, the finely powdered mineral with four times its weight of pure carbonate of barytes; digested the product with an excess of muriatic acid, which, leaving the silica undissolved, took up the baryta, alumina, &c.; precipitated the baryta by sulphuric acid, and the alumina by carbonate of ammonia; and then, evaporating to dryness the residuary liquor, and raising the heat so as to expel the ammoniacal salts, a saline residue was left, which was dissolved by water, with the exception of a small quantity of sulphate of lime. It was a neutral salt, consisting of the new substance in combination with sulphuric acid. The sulphate was decomposed by acetate of barytes, and the acetate of lithia, thus obtained, was converted by calcination into carbonate of lithia. For carbonate of barytes, Vauquelin and Gmelin advantageously substituted the nitrate.

Composition of Ammonia.—Vol. I. p. 199.

If hydrogen be made the decimal unit, and it be admitted that the three volumes of hydrogen in ammonia represent 3 atoms, and the 1 vol. of nitrogen, one atom, then the weights of the atoms of hydrogen and nitrogen will be as their specific gravities, viz. as .0694 to .970, or as 1 to 14. Ammonia, according to this view, will be constituted of three atoms of hydrogen = $3 + 1$ atom of nitrogen = 14, and its representative number will be 17.

ADDITIONS TO THE CHAPTER ON THE EARTHS.—
PART I. CHAP IX.

Preparation of the Peroxide of Barium.—Vol. I. p. 209.

THIS compound appears to be constituted of one atom of the metal = 70, + 2 atoms of oxygen = 16, together 86. To prepare the peroxide, Thenard recommends that the nitrate of baryta be ignited in a retort of white porcelain (one of Wedgwood's ware is well adapted to the purpose) till oxygen gas ceases to be evolved. The product, hastily broken into fragments about the size of a hazle nut, is to be put into a well-luted green glass tube, which is to be placed horizontally in a furnace, and heated to dull redness. A current of oxygen gas, dried by having first been passed over quicklime, is then to be transmitted through the tube, and continued 10 or 15 minutes. The gas is rapidly absorbed, and a grayish-white substance obtained, which is the *peroxide*, the compound employed by Thenard in giving an additional proportion of oxygen to water.

Method of obtaining Calcium.—Vol. I. p. 212.

To obtain calcium, a paste may be moulded, either of pure lime, or of sulphate of lime and water, into the shape of a small capsule, which may be placed on a metallic dish. Into this capsule, mercury may be poured, and connected with the negative extremity of a galvanic apparatus of sufficient power, while the positive wire of the same pile is made to touch the under surface of the metallic plate. When the contact has been continued sufficiently long, an amalgam of mercury and calcium is obtained, which may be put into a small retort, along with naphtha enough to cover it. The retort is then to be connected with a tubulated receiver, the tubulure of which is only loosely stopped with a cork. On applying heat, the naphtha first comes over; then the mercury; and the calcium remains, surrounded by an atmosphere of vapour of naphtha. As the vessels cool, it would be desirable, and would not be difficult, to fill them with nitrogen gas, to prevent the oxidation of the calcium.

Peroxide of Calcium.—Vol I. p. 213.

WHEN oxygen gas is passed over ignited quicklime, the gas is absorbed, and a peroxide of calcium is obtained; the exact composition of which has not been determined. A similar peroxide,

united with water, is formed also, according to Thenard, when lime is brought into contact with the oxygenated water, discovered by that chemist.

Ingredients of different Kinds of Glass.—Vol. I. p. 215.

FLINT Glass is formed of fine siliceous sand, pearlash, litharge or minium, a little nitre, and a small quantity of manganese; crown glass for windows, of soda, fine siliceous sand, lime, and fragments of glass; green bottle glass, of sand, kelp, pearlash, clay, and fragments of glass; and plate glass, of fine sand, soda, lime, manganese, oxide of cobalt, and fragments of glass. Pastes, or artificial gems, are only another variety of glass, into the composition of which borax generally enters, the colour being given by various metallic oxides.

Process of Dubois and Silveira for obtaining pure Zirconia.—
Vol. I. p. 219.

MM. DUBOIS and SILVEIRA have described the method of obtaining zirconia from zircons as follows: powder the zircons very fine, mix them with two parts of pure potassa; and heat them red-hot in a silver crucible for an hour. Treat the substance obtained with distilled water, pour it on a filter, and wash the insoluble part well; it will be a compound of zirconia, silica, potassa, and oxide of iron. Dissolve it in muriatic acid, and evaporate to dryness, to separate the silica. Re-dissolve the muriates of zirconia and iron in water; and to separate the zirconia which adheres to the silex, wash it with weak muriatic acid, and add it to the solution. Filter the fluid, and precipitate the zirconia and iron by pure ammonia; wash the precipitates well, and then treat the hydrates with oxalic acid, boiling them well together, that the acid may act on the iron, retaining it in solution while an insoluble oxalate of zirconia is formed. It is then to be filtered, and the oxalate washed, until no iron can be detected in the water which passes through. The earthy oxalate is, when dry, of an opaline colour; after being well washed, it is to be decomposed by heat in a platinum crucible.

Additional Characters of Zirconia.—Vol. I. p. 219.

It dissolves readily in acids. Its solution in muriatic acid, when sufficiently heated, becomes milk-white, and runs in some measure into a jelly, especially if concentrated to a certain point by evaporation.

From the muriatic solution of zirconia, oxalic acid throws down a white precipitate, which is re-dissolved by an excess of the acid.

It is precipitated from its acid solutions, by the neutral succi-

nates and benzoates, in copious white bulky flocks, which are again readily dissolved by an excess of succinic acid. It is also thrown down from its solutions by tartaric acid, malic acid, and tartrate of potassa.

From a sufficiently neutral solution of zirconia, ferrocyanate of potassa throws down a greenish-blue precipitate, which, on adding muriatic acid, becomes more blue, but after some time changes into celadon-green.

Hydrosulphuret of ammonia produces, in the muriatic solution of zirconia, a dark olive or blackish-green precipitate in very loose flocks. This precipitate may be washed with water without changing colour; but, when exposed to sunshine, it becomes white.

Professor Pfaff has remarked, that in most of their properties there is a striking resemblance between zirconia and oxide of titanium. The only re-agent, which acts in a strikingly different manner upon solutions of oxide of titanium and zirconia, is tincture of galls, which, from the common solution of oxide of titanium, throws down a reddish-brown precipitate, whereas from solution of zirconia, it occasions a deposition of yellow flocks. (Ann. of Phil. xiii. 88.)

ADDITIONS TO THE CHAPTER ON CARBONIC ACID AND
ITS BASE:—CARBONATES:—BINARY COMPOUNDS
OF CARBON.—PART I. CHAP. XI.

Preparation of Charcoal by the Distillation of Wood.—
Vol. I. p. 229.

IN the large way, charcoal is now most commonly prepared in this country by the distillation of wood in cast iron cylinders. The loppings of young trees, commonly called crop wood, are generally employed; and, besides the charcoal, liquid products of value are collected, especially an impure vinegar called *pyroligneous acid*. The process is described at length by Mr. Parkes in the 2d volume of his "Chemical Essays;" p. 271.

The charcoal of wood, besides its use as a fuel, is necessary to the preparation of that kind of iron which is used for wire; to the cementation of steel, and to the preparation of gunpowder. The charcoal prepared from coal, called *coke*, is less pure, and, beside

other substances, generally contains sulphur; but it has the advantage of being heavier and more compact, in consequence of which it is better adapted for burning in furnaces, in which there is a powerful blast of air.

Lamp black, a necessary ingredient of printing ink, is the condensed soot collected from the refuse resin of turpentine makers.

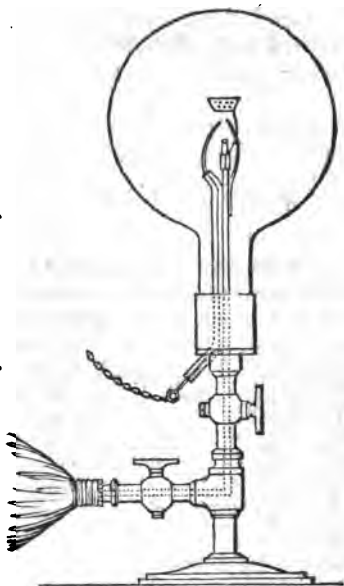
Fusion and Volatilization of Charcoal.—Vol. I. p. 229.

PROFESSOR Silliman, of Yale College, America, appears first to have observed, on subjecting cylindrical pieces of charcoal, tapered to a point, to the *galvanic deflagrator* of Dr. Hare, when in powerful action, that the charcoal point of the positive pole instantly shot out $\frac{1}{10}$ th, $\frac{1}{4}$ th, or even $\frac{1}{2}$ th of an inch. The charcoal of the negative pole underwent, in the mean time, a change precisely the reverse, its point disappearing, and a crater-shaped cavity being substituted in its stead. By placing a piece of metal at the negative pole in lieu of charcoal, it was ascertained by the absence of the usual phenomena, that the increase, before observed in the charcoal at the positive pole, was occasioned by an actual transference of charcoal, from the former to the latter. On examining with a magnifier the projecting point of the charcoal at the positive pole, it was found to have undergone distinct fusion into small spheres collected into botryoidal or mammillary concretions. (Ann. of Phil. iv. 119.)

These experiments have been repeated, with similar results, by Professor Griscom of New York. The charcoal, he observes, seems to pass over in the state of vapour, to be condensed on the positive pole, and then to undergo fusion by the intense heat. Charcoal, after being thus fused, is found to have become much harder, and to have acquired a great increase of specific gravity, sinking readily to the bottom of strong sulphuric acid. It is rendered so much less combustible, that it remains unaltered, when ignited on an iron plate with free access of air; but in a close vessel of oxygen gas, it was found entirely convertible into carbonic acid by the solar rays concentrated upon it by a powerful lens. Boiling sulphuric acid is scarcely changed by it; and in strong and heated nitric acid the effect is slight, and ceases the moment the heat is withdrawn. (American Journal of Science, v. 361.)

Apparatus for exhibiting the Combustion of the Diamond.
Vol. I. p. 234.

At the Royal Institution, an apparatus is employed for the combustion of the diamond, from which, with Mr. Brande's permission, the annexed sketch has been taken. It consists of a glass globe, capable of holding about 140 cubical inches, which, when used, is first exhausted, and then filled with oxygen gas. In the centre of this globe is supported a small hemispherical cup of platinum, pierced with small holes. This is destined for containing the diamonds; and beneath it, at the distance of about three quarters of an inch, is the orifice of a small pipe, from which a jet of hydrogen gas may be forced, by opening the cock and pressing the bladder. This stream of hydrogen being lighted by electric sparks, taken by means of a contrivance usually employed for such purposes, ignites the diamonds, and, when they are white-hot, the gas is extinguished by shutting the cock. The diamonds continue to burn till they are so much reduced in size that the cooling power of the platinum, with which they are in contact, prevents their farther combustion. After the apparatus has cooled, the gas within the globe will be found to have undergone an essential change, and to be partly converted into carbonic acid.



Composition of Carbonic Acid by Volume.—Vol. I. p. 234.

On the theory of volumes, the constitution of carbonic acid has been stated by Gay-Lussac to be 1 volume of gaseous carbon + 1 volume of oxygen, condensed into the space of 1 volume; and the density of the vapour of charcoal has been estimated to be equal to the density of carbonic acid, less that of oxygen gas. or to $1.5245 - 1.1025 = 0.422$. When two volumes of carbonic oxide are converted into carbonic acid, we add a volume of oxygen equal to that already existing in two measures of the former gas, viz.

one volume, and obtain two volumes of carbonic acid, which gas may therefore be considered, under this aspect, as constituted of one volume of carbonic oxide, + half a vol. of oxygen condensed into one volume.

Composition of the Carbonates of Soda.—Vol. I. p. 244.

Simple Carbonate of Soda.—On the supposition that dry carbonate of soda is constituted of 1 atom of acid = 22, + 1 atom of base = 32, its equivalent number will be 54, and it will consist of

Acid	. . .	41.23	. .	100.	. . .	70.15
Base	. . .	58.77	. .	142.54	. . .	100.
		<hr/>		<hr/>		<hr/>
		100.		242.54		170.15

And the crystallized salt will be constituted of one atom of dry carbonate = 54, + 7 atoms of water = 63, and its equivalent number will be 117. This gives for its composition, in 100 grains, 46.15 carbonate + 53.85 water. One hundred grains of the dry salt require for neutralization 460 grains of sulphuric acid of density 1.141; and hence the quantity of dry carbonate in the soda of commerce may be learned, by ascertaining the proportion of sulphuric acid, of that strength which 100 grains of any sample require for saturation.

Bi-carbonate of Soda appears to be constituted of 1 atom of soda = 32, + 2 atoms of carbonic acid = 44, and its equivalent number is 76; or it is composed of

Acid	. . .	58.4	. . .	100.	. . .	140.30
Base	. . .	41.6	. . .	71.27	. . .	100.
		<hr/>		<hr/>		<hr/>
		100.		171.27		240.30

But, according to Berard, 100 grains contain 20.2 grs. of water, which would indicate that each atom of the anhydrous salt is united with 2 atoms of water. The composition of the crystals then must be 1 atom of the dry salt = 76, + 2 atoms of water = 18, giving in all 94, for the equivalent number of the bi-carbonate in crystals. By exposure to a red heat, the whole of the water and one-half of the carbonic acid are expelled, and the salt is reduced to the state of simple carbonate.

Sesqui-carbonate.—A native carbonate of soda, found near Fezzan in Africa, and there called trona, has been analyzed by Mr. R. Phillips. He finds it to be a compound intermediate between the carbonate and bi-carbonate, or to be constituted of 3 atoms of acid + 2 of soda, or of $1\frac{1}{2}$ atoms of acid = 33, + 1 of soda = 32, together 65. Hence he has given it the name of sesqui-carbonate of soda. (Journ. of Science, &c. vii. 298.)

Composition of the Carbonates of Ammonia.—Vol. I. p. 246.

Carbonate of Ammonia consists of one volume of carbonic acid and two volumes of ammonia. which, when mingled over mercury in that proportion, undergo complete condensation. As 100 cubic inches of carbonic acid weigh 46.56 grains, and 200 of ammonia 36.36 grains, in all 82.92 grains, carbonate of ammonia must consist of

		Atom.	
Carbonic acid	. . . 56.20	. . . 1	. . . 22
Ammonia	. . . 43.80	. . . 1	. . . 17
	<hr/>		<hr/>
	100.		39

These proportions differ very little from the experimental results of Gay-Lussac (56.02 acid + 43.98 base).

Bi-carbonate of Ammonia crystallizes, when evaporated by a very gentle heat, in small six-sided prisms, has no smell, and but little taste. It consists, exclusive of water, of

		Atoms.	
Carbonic acid	. . . 2	. . . 44	
Ammonia	. . . 1	. . . 17	
		<hr/>	61

Sesqui-carbonate of Ammonia.—Besides these two compounds of ammonia and carbonic acid, there is another which is generally met with in the shops under the name of sub-carbonate of ammonia. It is produced by exposing to heat, in a proper subliming apparatus, a mixture of muriate of ammonia and carbonate of lime, and if no loss occurred during the operation, it ought to consist of 1 atom of carbonic acid, 1 of ammonia, and 1 of water. But the heat, which is necessary to the decomposition, expels both ammonia and carbonic acid, and the resulting salt has the following proportions:

	Acid.	Base.	Water.
According to Dr. Ure	. . . 54.5	. . . 30.5	. . . 15.
Mr. Phillips	. . . 54.2	. . . 29.3	. . . 16.5
Mr. Dalton	. . . 59.	. . . 24.5	. . . 16.5

The atomic constitution, nearest to the above proportions, and that which probably belongs to the salt in its perfect state, is as follows:

		Atoms.	
Acid	. . . 55.72	. . . 3	. . . 66
Base	. . . 29.	. . . 2	. . . 34
Water	. . . 15.28	. . . 2	. . . 18
	<hr/>		<hr/>
	100.		118

Viewing it as a compound of $1\frac{1}{2}$ portions of carbonic acid, 1 ammonia, and 1 of water, it has been called by Mr. Phillips a sesqui-carbonate; and if this view be unconnected with the notion

of its containing the fraction of an atom, there can be no objection to the name. It is preferable, indeed, to that of sub-carbonate, which should be reserved for the compound, hitherto unknown, of 1 atom of acid and 2 of base.

When the sesqui-carbonate is fresh prepared, it has a crystalline appearance and some transparency, and is hard and compact. It has a pungent smell, and a sharp penetrating taste, and affects vegetable blues as uncombined alkalies do. It dissolves in twice its weight of cold, or an equal weight of boiling water. When exposed to the atmosphere, it loses weight very fast, ceases to be transparent, loses its odour, and becomes brittle and easily reducible to powder. When its chemical composition is now examined, it is found to be identical with the bi-carbonate, or to consist of

Two atoms of acid	44
One atom of base	17
Two atoms of water	18
	<hr/>
	79

It has, therefore, lost by exposure, 1 atom of acid and 1 atom of base.

By varying the proportions of the ingredients, and the regulation of the heat, it is possible to obtain a bi-carbonate at once by sublimation. (Annals of Philos. N. S. iii. 110.)

Composition of the Carbonates of Magnesia.—Vol. I. p. 252.

Common Carbonate of Magnesia.—Berzelius is of opinion, that this salt is a compound of three atoms of carbonate of magnesia with one atom of the hydrate of the same earth; and if, as appears to me probable, this be the correct view of its composition, it will consist of

3 atoms of carbonate $42 \times 3 =$	126	72.77
1 atom of tri-hydrate $20 + 27 =$	47	27.23
	<hr/>	<hr/>
	173	100.

Or, of

Magnesia in the carbonate . . .	34.34	} 45.82
Ditto in the hydrate	11.48	
Carbonic acid	38.42	
Water	15.76	
	<hr/>	<hr/>
	100.	

The true carbonate of magnesia, consisting of 1 atom of acid + 1 atom of base, though it has not yet been formed artificially, is found as a natural product, and, being entirely without water,

it may be called the *anhydrous carbonate of magnesia*. A specimen of this mineral from the East Indies, I have analyzed and described in the *Annals of Phil. N. S. i.* 252.

Saturated Carbonate of Magnesia.—Some crystals of this salt, I analyzed several years ago, and showed them to consist of, base 29, acid 30, water 41. Berzelius, from the examination of a specimen probably purer than mine, deduced its proportions to be, base 29.583. acid 31.503, water 38.914. There can be little doubt that its true constitution is as follows, and that it is a carbonate and not, as has been supposed, a *bi-carbonate*, a salt which, in fact, has not yet been proved to exist; *viz.*

1 atom of magnesia	20	28.60
1 atom carbonic acid	22	32.
3 atoms water	27	39.40
	<hr/>	
	69	100.

Water at 60° dissolves only 1-2493d of its weight, and, at the boiling temperature, 1-9000th part, of common carbonate of magnesia. (*Edinb. Journ. v.* 305.) The addition of almost any acid to the carbonate expels its carbonic acid, and a compound remains of magnesia with the new acid which has been added. The affinity of carbonic acid for magnesia appears, indeed, to be feeble, for it is expelled by a very moderate heat, much inferior to that required for the decomposition of carbonate of lime. The residue is pure magnesia, which, for medicinal and chemical uses, is always prepared by the calcination of the carbonate, and hence its name of *calcined magnesia*.

Carbonate of Magnesia and Potassa.—Berzelius has described a salt with double base, which may be formed by mixing bi-carbonate of potassa in excess with muriate of magnesia. No precipitate appears; but, in a few days, the salt arranges itself in crystalline groups on the sides of the vessel. It consists of

Potassa	18.28
Magnesia	15.99
Carbonic acid	34.49
Water	31.24
	<hr/>
	100.

Combinations of Hydrogen with Carbon.—Vol. I. p. 254.

ONLY two distinct and well-characterized compounds of hydrogen and carbon are at present known; for though it has been contended, by some chemical writers, that these two elements are capable of uniting in almost all proportions, yet there seems no reason for believing, that, in this instance, there is any departure from the general law, that bodies combine in proportions which

are few in number, and which are either equal, or are simple multiples or divisors of each other.

The union of hydrogen with carbon cannot be effected by heating charcoal in hydrogen gas; for the cohesive attraction of the particles of charcoal prevents the combination. It may be effected, however, by exposing to a high temperature some of the solid and liquid compounds of hydrogen and charcoal, and it is produced also by several natural operations, especially by animal and vegetable putrefaction. The gas which has a minimum of carbon may be called, simply, carburetted hydrogen gas.

Carburetted Hydrogen Gas.—It has been distinguished also by the name of *heavy inflammable air, gas of marshes, hydro-carburet, proto-carburet of hydrogen*, and has been termed by Dr. Thomson, *bi-hydroguret of carbon*.

This gas may be obtained, mixed, however, with about $\frac{1}{30}$ of carbonic acid, and $\frac{1}{12}$ or $\frac{1}{20}$ of nitrogen gas, by stirring the bottom of almost any stagnant pool of water, especially if formed of clay. When this is done by an assistant, the gas is copiously disengaged in bubbles, which may be collected either in an inverted glass jar, or in an inverted bottle filled with water, into the mouth of which a funnel is fixed. It should be washed, when collected, with lime-water or liquid potash.

It may, also, be procured by the purification of gas from coal, by means of chlorine and solution of potash, applied in succession, in a manner which will be described in speaking of coal gas. [See next article of this supplement.]

Carburetted hydrogen, thus obtained, is permanent over water, which, after being well purged of air by boiling, is capable of taking up about $\frac{1}{12}$ of its bulk. It has very little odour, the strong and disagreeable smell of coal gas being dependent on foreign admixtures. Its specific gravity, from Dr. Thomson's experiments and my own, is 0.555; and hence 100 cubic inches, at a mean of the barometer and thermometer, weigh 16.95 grains.

When set on fire as it issues from a small orifice, it burns with a yellow flame, giving out vastly more light than hydrogen gas. When mixed with atmospheric air, it may be kindled by a lighted taper, and it explodes with violence, provided it forms not less than $\frac{1}{12}$ th of the mixture, and does not exceed $\frac{1}{4}$ th. With oxygen gas, the detonation is louder and more violent; but it is necessary that the oxygen should rather exceed the inflammable gas in volume, and yet should not be more than $2\frac{1}{4}$ times its bulk. Under a pressure diminished below one-fourth that of the atmosphere, the mixture ceases to be combustible; and its inflammability is also much lessened, by mingling it with carbonic acid and some other gases. To burn it completely, it is necessary to use more than twice its volume of oxygen gas, of which exactly two volumes are consumed, and carbonic acid is produced, equivalent in volume to the inflammable gas. Now we know that in carbonic acid gas there exists exactly its volume of oxygen; and hence one volume of the oxygen spent is found in that compound, and the

other volume has formed water with the hydrogen, which last element must have existed in quantity equivalent to twice the bulk of the inflammable gas. The water produced may be collected by the slow combustion of the gas; but this is not necessary for calculating the proportion of its elements, which may be correctly estimated as follows. Since 100 cubic inches (= 16.95 grains) afford by combustion 100 cubic inches of carbonic acid, weighing 46.5 grains, and containing 12.69 grains of carbon, then $16.95 - 12.69 = 4.26$ is the hydrogen in 100 cubic inches of carburetted hydrogen, which is, therefore, constituted of

	Grains.	Grains.	Grains.
Charcoal	12.69	74.87	100.
Hydrogen	4.26	25.13	33.41
	<hr/> 16.95	<hr/> 100.	<hr/> 133.41

Or carburetted hydrogen gas may be stated to be composed of 2 volumes of hydrogen and 1 volume of gaseous carbon condensed into 1 volume. But 2 volumes of hydrogen, requiring 1 volume of oxygen to form the binary compound, water, which we have already considered to be constituted of an atom of each element,* the atomic constitution of carburetted hydrogen will be 1 atom of charcoal (= 6) + 2 atoms of hydrogen, (= 2), and the compound atom will weigh 8. From this view of its constitution, the name proposed by Dr. Thomson (bi-hydroguret of carbon) is certainly most appropriate, and it is only to avoid the inconvenience of laying aside one which is sanctioned by long usage, that I employ that of carburetted hydrogen.

When carburetted hydrogen and chlorine gases are mixed together, no change happens either immediately or on standing, provided light be carefully excluded; but if exposed to the ordinary light of day, and still more rapidly in sunshine, a mutual action ensues. If 4 volumes of chlorine, and 1 of carburetted hydrogen, be thus kept, during a few hours, in a bottle filled entirely with the mixture, and furnished with a well-ground stopper, on removing this under water, a sudden absorption of muriatic acid gas takes place, and 1 volume of carbonic acid remains. Three volumes of chlorine and one of carburetted hydrogen afford a residue of carbonic oxide. In both cases, water is decomposed, (for the gases do not act on each other if perfectly dry), the oxy-

* This statement, as it stands, certainly affords no reason for the presence of 2 atoms of hydrogen in this gas. The fact, however, rests upon this circumstance, that as the 1 volume of gaseous carbon is assumed to be equivalent to 1 atom, 1 volume of oxygen will be equivalent to 2 atoms, carbonic acid being composed of equal volumes of its constituents, and containing 2 atoms of oxygen. If then 1 volume of oxygen, in this case, be equal to 2 atoms, it follows, upon the assumed atomic constitution of water, that the 2 volumes of hydrogen, which saturate it, must be equal to 2 atoms also.—B.

gen of the water uniting with the carbon, and its hydrogen with the chlorine. If the quantities be sufficiently large, and the sun's rays fall on the mixture, a detonation ensues, which may also be produced either by an electric spark, or by a lighted taper.

Bi-carburetted Hydrogen, or Olefant Gas.—This gas was discovered by the associated Dutch chemists, and was termed by them *olefant gas*. It has since been called *bi-carburetted* or *per-carburetted hydrogen*, and by Dr. Thomson, *hydroguret of carbon*. It may readily be obtained by distilling, in a glass retort, with a gentle heat, three measures of concentrated sulphuric acid, and one measure of alcohol. The mixture soon assumes a black colour and thick consistence, and a gas is disengaged which may be collected over water, and freed from carbonic acid by washing it with liquid potash. If left to stand long over water, it sustains a diminution, that fluid being capable of taking up $\frac{1}{4}$ th of its volume of the gas.

Bi-carburetted hydrogen, when pure, has very little odour, except when mingled with a little sulphuric ether, which is formed along with it. Its specific gravity is stated by the Dutch chemists at .909; by my experiments, made several years ago, it is .967; by those of Saussure, jun. .9852; and by Dr. Thomson's latest trials .970. According to the last mentioned result, 100 cubic inches, at a mean of the barometer and thermometer, weigh 29.64 grains.

This gas, when set on fire as it issues from the orifice of a small pipe, burns with a remarkably dense and bright flame, very superior to that of simple carburetted hydrogen. When mingled with oxygen gas, it detonates very loudly and forcibly, and, if fired by electricity in a Volta's eudiometer, is apt, unless very small quantities be employed, to burst the instrument. One volume requires for saturation three volumes of pure oxygen gas, and affords two volumes of carbonic acid gas. But in order to insure the perfect combustion of the inflammable gas, it should be mixed with 5 times its bulk of oxygen, of at least 90 per cent purity. If too little oxygen be used, charcoal is apt to be precipitated unburned; and the excess of oxygen does no harm, but remains in the mixture. When fired with less than its own bulk of oxygen, the separation of charcoal is very evident, and the bulk of the residue is greater than that of the original gases.

Calculating the constitution of this gas, from the oxygen spent in its combustion and the carbonic acid formed, precisely as was done with respect to carburetted hydrogen, we have the following results, the first column including the composition of 100 cubical inches.

	Grains.	Grains.	Grains.
Charcoal	25.38	85.63	100.
Hydrogen	4.26	14.37	16.71
	<hr/> 29.64	<hr/> 100.	<hr/> 116.71

In this gas, therefore, 100 grains of charcoal are united with 16.71 hydrogen, and in the last with 33.41; or, as nearly as possible, olefiant gas contains only one-half the hydrogen. Its constitution may hence be stated as follows:

	Vols. of Carb.	Vols. of Hydr.	At. of Carb.	At. of Hydr.			
In each volume . . .	2	+	2	=	1	+	1

The compound atom, therefore, will weigh $6 + 1 = 7$. Its greater combustibility evidently depends on its containing, in a given volume, twice the quantity of carbonaceous matter that is present in simple carburetted hydrogen.

When olefiant and chlorine gases are mixed together in equal quantities, an immediate diminution ensues; and this effect takes place, even when the vessel is shaded from the light by an opaque cover. It is therefore wholly independent of the agency of light, and may be made the basis of a method of analyzing a mixture of olefiant and carburetted hydrogen gases. For, of the diminution thus produced, one-half is due to the olefiant, and one-half to the chlorine gas, those gases having been ascertained to saturate each other in equal volumes. Into a graduated tube standing over water, admit 30 or 40 measures of chlorine gas, and note its bulk when actually in the tube, which must be shaded by an opaque cover. Then add a known quantity (suppose 50 measures) of the gas under examination; and, after ten minutes, cautiously lift the outer cover, till the surface of the water appears. If the volume of the two gases has suffered no diminution, we may infer the absence of olefiant gas; but if the united bulk of the two gases be less than the sum of their separate volumes, divide the diminution by 2, and the quotient will show how much olefiant gas has been condensed. In this way I have found, that olefiant and carburetted hydrogen gases may be accurately separated from each other; but it is necessary to use a slight excess of chlorine, which may afterwards be removed by washing the residue with liquid potash, and the carburetted hydrogen will then be obtained pure.

When iodine and olefiant gas are exposed to the sun's rays, the two substances unite, and form colourless crystals. When the redundant iodine has been washed away by liquid potash, and the residue collected and dried, it is a solid white crystalline body, heavier than sulphuric acid; having a sweet taste and an aromatic smell; friable, and a nonconductor of electricity; fusible, and capable of being sublimed at a moderate heat without change; but decomposed by a strong heat. It is not readily combustible, but, when held in the flame of a spirit lamp, burns, diminishing the flame, and giving off abundance of iodine and some fumes of hydriodic acid. It is insoluble in water, and in acid and alkaline solutions; but dissolves in alcohol and in ether. It may be termed *hydriodide of carbon, or hydro-carburet of iodine*. (Faraday, Phil. Trans, 1821.) From a recent analysis by Mr. Faraday, it

appears to consist of 1 atom of iodine + 2 atoms of olefiant gas. (Quarterly Journal, xiii. 429.)

Mixed Combustible Gases from Moist Charcoal, Alcohol, Ether, Coal, Oil, Tallow and Wax.—Vol. I. p. 258.

The two gases, which have been just described under the names of carburetted and bi-carburetted hydrogen, appear to me to be the only compounds of those elements, that have as yet been proved to be distinct and well-characterized species; though it is extremely probable, as I have shown in the Phil. Trans. for 1820, that another gas exists, which was first observed by Mr. Dalton, is heavier and more combustible than olefiant gas, and contains a larger proportion of carbon. It is of mixtures of two or more of those three gases, with occasionally a proportion of carbonic oxide, that the almost infinite variety of æriform products are constituted, which are obtainable by the exposure of moistened charcoal, of alcohol or ether, of oil, tallow, wax, or coal, to a heat a little above ignition. This view of the subject, at least, appears to me much more probable, than that they are so many distinct compounds of carbon and hydrogen, which, on this theory, would be capable of uniting in all possible proportions with each other.

Of these æriform compounds, the gases from coal and from oil are of most importance, from their widely extended use in artificial illumination.

Coal Gas.—By submitting coal to distillation in an iron retort, besides a portion of tar and solution of carbonate of ammonia, which condense in a liquid form, a large quantity of permanent gas is evolved. This gas I have shown (Phil. Trans. 1808 and 1820) is extremely variable in composition and properties, not only when prepared from different coals, but from the same kind of coal under different circumstances. Within certain limits, the more quickly the heat is applied, the greater is the quantity, and the better the quality, of the gas obtained from coal; for too slow a heat expels the inflammable matter in the form of tar. The early products of gas are, also, the heaviest and most combustible, and there is a gradual decline in quality towards the close of the distillation, inasmuch that the last products are inferior, by more than one-half, to the first. The general name of *coal gas* is, therefore, quite indefinite. It is, in fact, a mixture of the two varieties of carburetted hydrogen, with a third which remains to be more fully investigated, as well as with hydrogen gas, carbonic oxide, carbonic acid, nitrogen, and sulphuretted hydrogen gases, in ever-varying proportions. To describe the methods of separating these gases from each other, would lead into minute details, and I refer, therefore, to the papers, which I have published in the Phil. Trans.

for 1808 and 1820, and in the 3d vol. 2d. Series, of the Manchester Society's Memoirs, or Annals of Philosophy, vol. xv.

Coal gas, as generally procured, has a very disagreeable odour, arising from sulphuretted hydrogen, and, perhaps, a little sulphuret of carbon; but both these may be washed out of it by cream of lime, with (as I have shown) very little loss of illuminating power, and with an entire removal of all unpleasant smell either before or during burning. The best gas has the specific gravity .650 or upwards; and each volume consumes about $2\frac{1}{4}$ volumes of oxygen and gives $1\frac{1}{4}$ volume of carbonic acid; the last portions have a specific gravity as low as .340, and each volume consumes about 8-10ths of a volume of oxygen, and gives about 3-10ths of a volume of carbonic acid. In the best gas, chlorine, applied as directed page 51, detects from 13 to 20 per cent. of olefiant gas, and the remainder is almost pure carburetted hydrogen: but the last products contain little or no olefiant gas, much less carburetted hydrogen, and, instead of these, a large proportion of hydrogen and carbonic oxide, both of which afford very little light by their combustion.

It is scarcely possible to assign the quantity of gas, which ought to be obtained from a given weight of coal; but it may be considered as an approach to a general average to state, that 112lbs. of good coal are capable of giving from 450 to 500 cubic feet of gas of such quality, that half a cubic foot per hour is equivalent to a mould candle of six to the pound, burning during the same space of time.

Oil Gas.—In Nicholson's Journal for 1805, I have given an account of some experiments on the gas obtained by the destructive distillation of spermaceti oil, which showed that of all the artificial gases, this, next to olefiant gas, consumes most oxygen, and is the best adapted to afford light. Since that time, an apparatus has been invented by Messrs. Taylor, of London, which has greatly facilitated the preparation of oil gas on a large scale, and this gas is now much used as a source of artificial light. The process consists in letting whale oil (the purity of which is not essential, since very inferior oil answers the purpose) fall by drops into an iron cylinder placed horizontally in a furnace, and ignited to a cherry redness. From each wine gallon of oil, about 100 cubic feet of gas may with care be obtained, of the specific gravity of more than .900, containing upwards of 40 per cent. of gas condensable by chlorine, and of which 100 volumes consume 260 volumes of oxygen, and yield 158 of carbonic acid. But of gas from Wigan canal, when the whole product is mingled together, 100 measures do not saturate more than 155 of oxygen, and give 88 measures of carbonic acid. Oil gas, therefore, from this document, may be inferred to contain, in a given volume, twice the quantity of combustible matter that is present in the average of gas from canal coal; and its illuminating power will be as 2 to 1. The experiments of Mr. Brande led him to conclude, that to pro-

duce the light of ten wax candles for one hour, there will be required

2600 cubical inches of olefiant gas.
4875 oil gas.
13120 coal gas.

But it seems probable that the coal gas, employed in these experiments, was below the general standard, and that it is a fair average to consider 1 volume of oil gas as equivalent to 2 or at most $2\frac{1}{2}$ volumes of gas from coal of good quality. This estimate agrees with the experience of the late Mr. Creighton, of Glasgow, author of the excellent article 'Gas Lights,' in the Supplement now publishing to the Encyclop. Britan. Oil gas he considers as superior, in an equal volume, to good average coal gas, in the proportion of only 2 to 1; and he has given the following Table of the comparative expense of lighting with these two gases, and with oil and tallow.

	s.	d.
Valuing the quantity of light which 1lb. of tallow gives in candles at	1	0
An equal quantity of light from sperm. oil, consumed in an Argand's lamp, will cost	0	$6\frac{1}{2}$
Do. from whale oil gas	0	$4\frac{1}{2}$
Do. from coal gas	0	$2\frac{3}{4}$

Twenty cubic feet of coal gas, or ten of oil gas, he considers as equivalent to a pound of tallow, and 5000 grains of good sperm. oil to 7000 of tallow, or 1lb. avoirdupois.

The advantages of oil gas over gas from coal are, that smaller distilling vessels are required; that gazometers and conduit pipes of half the capacity are sufficient; that no washing apparatus is necessary; that the trouble and expense of removing waste materials is avoided; and that the gas affords a much brighter light, and with a smaller production of heat, and also of water. When only a moderate quantity of light is required; when it is an object to save room or labour; and in countries where coal is dear, oil gas is entitled to a decided preference; but it cannot be brought into competition with coal gas, where coal is cheap, or where the establishments to be lighted are of very considerable magnitude, and of such a nature as to allow of their being freely ventilated.

Of the comparative value of different compounds of hydrogen and charcoal for the purpose of illumination, it still appears to me that the only accurate test is the one which I proposed in Nicholson's Journal for 1805, viz. the quantities of oxygen gas required to saturate equal volumes. If 100 measures, for instance, of one gas, require for perfect combustion 100 measures of oxygen, and 100 measures of another gas take 200 of oxygen, the

value of the second will be double that of the first. Specific gravity, though a guide to a certain extent, is not a sufficient one; for the weight of a gas may be owing to a large proportion of carbonic oxide, which is capable of giving out only a very small quantity of light. Photometrical experiments, also, appear to me to require greater perfection in the instruments that have been invented for that purpose, before we can implicitly trust to results obtained by their means; but there can be no fallacy in the combustion of these gases by oxygen, if conducted with ordinary care, and especially if, in each instance, an average be taken of two or three trials, which need not occupy more than a few minutes. Nor can it admit of a doubt, that, other circumstances being equal, the brilliancy of light, evolved by the combustion of gases which are constituted of purely inflammable matter, will bear a proportion to their densities, perhaps even a greater proportion than one strictly arithmetical; because, while, by the combustion of denser gases, a higher temperature is produced, the cooling agencies remain the same. It is probable, therefore, that of two gases, composed of the same ingredients, that which has a double density will afford somewhat more than a double quantity of light.

Hydro-cyanic or Prussic Acid:—Chloro-cyanic Acid:—Sulpho-cyanic Acid:—Ferro-cyanic Acid.—Vol. I. p. 261.

Hydro-cyanic or Prussic Acid.—From the *prussiate*, or more correctly *cyanide of mercury*, hydro-cyanic acid may be obtained by distillation with muriatic acid, taking care to employ a proportion of the latter which is not sufficient to saturate the metallic base of the salt. The neck of the retort must be prolonged, for about two feet, by a glass tube of at least half an inch bore placed horizontally, and containing in the $\frac{1}{3}$ d next the retort, small pieces of white marble, in the other $\frac{2}{3}$ ds, fused chloride of calcium. To the end of this tube, a small receiver must be luted, and be kept cool by a freezing mixture. Hydro-cyanic acid, along with muriatic acid and watery vapour, will be disengaged on gently heating the retort, the two last of which will be condensed by the materials in the tube, while the first, by successively heating the different parts of the tube, may be driven onwards to the receiver.

On repeating this process, Vauquelin found the product of hydro-cyanic acid so extremely small, that he was induced to seek for a better method of obtaining it. He succeeded by passing a current of sulphuretted hydrogen gas, disengaged from sulphuret of iron and sulphuric acid, very slowly, through a glass tube slightly heated and filled with cyanide of mercury, its extremity ending in a receiver which was kept cool by a mixture of snow and salt. The process was carried on till the smell of sulphuretted hydrogen, which for a long time could not be perceived,

was discovered in the receiver. The hydro-cyanic acid amounted in weight to $\frac{1}{4}$ th the cyanide of mercury. To avoid any inconvenience from the process being carried too far, some carbonate of lead was placed at the end of the tube next the receiver, in order to absorb the sulphuretted hydrogen that might pass undecomposed.

The hydro-cyanic acid is subject to spontaneous decomposition, and the more so, the greater its state of concentration. For medical use, into which it has been of late years introduced, it may be obtained by dissolving 60 grains of cyanide of mercury in each ounce of water, and passing a current of sulphuretted hydrogen gas through the solution, till the liquid contains a slight excess of it, which may be separated by a little carbonate of lead; after which the fluid may be filtered.

The process adopted at Apothecaries' Hall, London, is the following. One pound of cyanide of mercury is put into a tubulated retort with six pints of water and one pound of muriatic acid, sp. gr. 1.15; a capacious receiver is luted to the retort; and six pints are distilled over. The specific gravity of the product is 0.995; it must be preserved in bottles excluded from the light, and being subject to decomposition should not be long kept. (Brande's Manual, i. 140.) The specific gravity of the acid is considered by Dr. Ure as an inadequate test of its strength; and he recommends the following as a more simple method of analysis. "To 100 grains, or any other convenient quantity, of the acid, contained in a small vial, add, in succession, small quantities of the peroxide of mercury in fine powder, till it ceases to be dissolved on agitation. The weight of the oxide taken up, being divided by four, gives a quotient representing the quantity of real prussic acid present. By weighing out beforehand on a watch glass 40 or 50 grains of the peroxide, the residual weight of it shows at once the quantity expended." (Quarterly Journal, xiii. 312.)

When potassium is heated in hydro-cyanic vapour, it evolves hydrogen gas equal to half the volume of the vapour. The other elements of the gas unite with the potassium. Thus the hydro-cyanic acid is resolved into hydrogen and cyanogen, which last, uniting with the potassium, forms a cyanide of that metal. As hydro-cyanic acid is constituted of equal volumes of those two gases, united without condensation, the specific gravity of the acid gas ought to be the mean of those of its components, viz. 0.9360 very nearly. This differs very little from the result of experiments, viz. 0.9476. Its constituents, therefore, are by weight,

Cyanogen	100.
Hydrogen	3.846

or two atoms of charcoal = 12, + 1 of nitrogen = 14, + 1 of hydrogen; and its equivalent number is 27.

The salts formed by the union of this acid with salifiable bases are called *hydro-cyanates*, but they are not permanent, and have

no useful properties. They are decomposed by the weakest acids, such as the carbonic.

Hydro-cyanate of ammonia crystallizes in cubes or in very small prisms. Its volatility is such that at a temperature of 72° Fahr. its vapour supports a column of upwards of 15 inches of mercury; and at 97° Fahr. it is equal to the pressure of the atmosphere. Dr. Thomson finds that when prussian blue is exposed to a red heat in a copper tube, and the products received over mercury, the glass receiver is coated with transparent crystals of this salt. The solution of this salt precipitates several metallic solutions not affected by hydro-cyanic acid, which, according to Scheele, acts only on nitrates of silver and mercury, and on carbonate of iron. (Ann. of Phil. xv. 394.)

Chloro-cyanic Acid.—Chloro-cyanic acid was discovered by Berthollet, who found that hydro-cyanic acid, by absorbing chlorine, acquires new properties, and no longer forms a blue precipitate with the solutions of iron. Supposing it to result from the union of oxygen with the prussic acid, he gave to the new compound the name of *oxy-prussic acid*. The nature of this combination has since been investigated by Gay-Lussac. To prepare it, a current of chlorine gas may be passed through a solution of hydro-cyanic acid in water, till the liquid discolours the solution of indigo in sulphuric acid. By agitating this liquid with mercury, and by distilling at a gentle heat, an elastic fluid is formed. This, however, is not pure chloro-cyanic acid, for at temperatures from 60° to 70° Fahr., and under common pressures, that acid can only exist as a liquid. It is a mixture of carbonic acid and chloro-cyanic acids, in proportions not yet determined.

The mixture of carbonic and chloro-cyanic acids is colourless; it has a very penetrating smell, and excites a flow of tears; its density, determined by calculation, is 2.123, air being 1. It reddens litmus, is not inflammable, and does not detonate by passing an electric spark through a mixture of the gas, with twice its volume of hydrogen or of oxygen; but with a mixture of the two, it burns vividly, with the production of a bluish-white flame and of an extremely dense white vapour, which has the smell of nitrous gas and the taste of a mercurial salt.

When potassium is heated in the mixed gases, the chloro-cyanic acid is entirely decomposed; the chlorine and cyanogen are absorbed; and the carbonic acid mingled with it undergoes a decomposition more or less complete.

The watery solution of the mixed acids does not precipitate either barytic water or nitrate of silver; but from the latter it produces, after being mixed with potash and then with nitric acid, a precipitate of chloride of silver.

Alcaline solutions absorb it rapidly, but do not destroy its odour, except when they are in excess. These compounds, on the addition of acids, are decomposed; a brisk effervescence arises in consequence of the escape of carbonic acid, water and chloro-

cyanic acid are reciprocally decomposed, and muriatic acid and ammonia are generated.

A characteristic property of this acid is, that with the intervention of potash, it forms green precipitates from solutions in which the iron is oxidized to a minimum. The experiment only succeeds when we first add the chloro-cyanic acid to the metallic solution, then a little alkali, and finally a small portion of acid.

According to the analysis of Gay-Lussac, this acid is constituted of

1 vol. of gaseous carbon	} condensed into	
$\frac{1}{2}$ a volume of nitrogen		} 1 volume.
$\frac{1}{2}$ ————— chlorine		

In other words, 1 vol. of chlorine and 1 vol. of cyanogen produce, by combining, 2 vols. of chloro-cyanic acid. Hence its density should be the mean of those of its components.

Sulpho-cyanic Acid.—This acid was discovered by Mr. Porrett, to whom we are indebted for a number of curious and interesting experiments on all the acids having cyanogen for their base. He gave it the name of *sulphuretted chyazic acid*, the term chyazic being compounded of the first letter of carbon, the first syllables of hydrogen and azote, with the usual termination signifying an acid. He considered it as a compound of sulphur with hydro-cyanic acid; but since the researches of Gay-Lussac, it may rather be regarded as a compound of sulphur with cyanogen.

The original process of Mr. Porrett is somewhat complicated and tedious. The following method was contrived by Grotthus, and improved by Vogel. Mix equal weights of pulverized ferro-cyanate (commonly called prussiate) of potash and flowers of sulphur, and expose the mixture in a flask to a heat sufficient to melt the sulphur, keeping it melted for several hours. When cold, reduce the mass to powder, and digest it in water enough to take up every thing soluble. Filter the liquor, and drop into it a sufficient quantity of potash to precipitate any iron that may be held in solution. The liquid, thus prepared, is a solution of sulpho-cyanate of potash in water, and the acid ingredient may be obtained, mixed with water, by distilling it with sulphuric acid.

Sulpho-cyanic acid, thus obtained, is a transparent liquid, colourless, or with a slight pinkish hue, with an odour as strong as, and somewhat resembling, that of acetic acid. The strongest obtained by Mr. Porrett had the specific gravity 1.022. It dissolves a little more sulphur at a boiling temperature; but most of this is separated again on cooling. In this state, it throws down oxide of silver from the nitrate, of a dark colour, but otherwise the precipitate is white.

Sulpho-cyanic acid boils at $216\frac{1}{2}^{\circ}$; and at $54\frac{1}{2}^{\circ}$ crystallizes in six-sided prisms. When thrown into a red-hot platinum crucible, sulphur is disengaged, and a blue flame is produced. It is partially decomposed by being transmitted through a red-hot porce-

lain tube; and if brought into contact with ignited iron turnings, sulphuret of iron is formed, and hydro-cyanic acid and sulphuretted hydrogen disengaged.

By a sufficient quantity of chlorine, the whole of the sulphur is converted into sulphuric acid, and hydro-cyanic acid is disengaged. Iodine produces a similar effect.

With protoxide of copper, it affords a white insoluble sulphocyanate. From the analysis of this salt, Mr. Porrett drew his inference respecting the composition of the acid, which he conceived to consist of one-third by weight of the elements of hydro-cyanic acid, and two-thirds of sulphur. According to Dr. Thomson, (System, 6th edit. ii. 306.), it is constituted of

2 atoms of sulphur	32
2 atoms of charcoal	12
1 atom of nitrogen	14
1 atom of hydrogen	1
	<hr/>

Hence its equivalent number is 59

It is capable of uniting with salifiable bases, and composes a genus of salts called *sulpho-cyanates*. Many of these have been investigated by Mr. Porrett.

Ferro-cyanic Acid.—The ferro-cyanic acid may be prepared by the following process: dissolve in cold water any quantity of the salt called triple prussiate (ferro-cyanate) of baryta, and for every ten grains so dissolved add a quantity of sulphuric acid equivalent to 2.53 grains of real acid; stir the mixture; and set it aside for some time. The baryta and sulphuric acid are precipitated in combination; and the ferro-cyanic acid may be decanted for use.

Mr. Porrett has also pointed out a method of obtaining ferro-cyanic acid in a crystallized form. Dissolve 58 grains of crystallized tartaric acid in alcohol, and 50 grains of ferro-cyanate of potash in as little warm water as possible. Mix the two liquids. Bi-tartrate of potash is precipitated, and the ferro-cyanic acid remains in solution. By spontaneous evaporation, it crystallizes in small yellow cubes, which, on exposure to the light, lose their regular shape, are decomposed, and become coated with prussian blue. It appears, therefore, that the balance of affinities preserving this acid is very soon disturbed, and its elements easily thrown into new arrangements.

The precise constitution of ferro-cyanic acid does not appear to have been as yet satisfactorily made out; nor even is it absolutely certain that it contains hydrogen as an essential element. It is possible that it may be a compound, not of hydro-cyanic acid, but of cyanogen, with protoxide of iron: Or the compounds called triple prussiates may be hydrocyanates with a double base. The greater permanency of these salts than of mere hydro-cyanates, may, as observed by Gay-Lussac and Berzelius, (who admit the facts of Mr. Porrett, but dissent from his conclusions), be an-

alogous to what happens in some other cases. Thus alumina, when associated with potash, enters into more energetic union with sulphuric acid, than singly by itself.

According to the latest analysis by Mr. Porrett, ferro-cyanic acid consists of 1 atom of hydro-cyanic acid + 2 atoms of charcoal + 1 atom of metallic iron. M. Robiquet, on the other hand, regards it as compounded of the elements of hydro-cyanic acid and of cyanide of iron, in the same manner as we may conceive alcohol to be formed of water and bi-carburetted hydrogen. (Ann. de Ch. et Phys. xvii. 197.) Berzelius has been led to adopt the opinion, that ferro-cyanic acid is merely a hydro-cyanate of protoxide of iron with excess of acid. In the present state of the inquiry, it seems impossible to determine which of these is the correct view; and a further appeal to experiment must be made, before we can decide respecting the true nature of the ferro-cyanic acid. Its present name may, therefore, be considered as only provisionally adopted, till its constitution is more accurately known.

Compounds of Cyanogen, and of the acids formed from it, with Potassa.—Vol. I. p. 261.

Cyanide of Potassa.—Cyanogen is absorbed by liquid hydrate of potassa, and a solution is obtained, which has scarcely any colour, unless the cyanogen is in excess, when it becomes brown, and apparently carbonaceous. This solution affords prussian blue when added to an acid solution of iron, carbonic acid escaping, and a smell of hydro-cyanic acid being at the same time perceptible. The volume of carbonic acid produced, it has been shown by Gay-Lussac, is precisely equal to that of the cyanogen absorbed, and he has rendered it extremely probable that hydro-cyanic acid and ammonia are at the same time generated.

Hydro-cyanate of Potassa may be formed by the mixture of hydro-cyanic acid, and liquid hydrate of potassa. It is very soluble, is alkaline to the taste, and turns sirup of violets green. It is decomposed by the weaker acids, even by the carbonic. With salts having protoxide of iron for a base, it gives a precipitate which is at first orange-coloured, and afterwards, by exposure to the air, changes successively to green and to deep blue. From solutions containing peroxide of iron, it causes a pale blue precipitate, the colour of which becomes deeper by exposure to air. When calcined, the acid ingredient abandons its hydrogen, and the salt becomes a *cyanide of potassa*.

Ferro-cyanate of Potassa.—When the salt just described is digested in a state of solution with protoxide of iron, a portion of the oxide is dissolved, the solution becomes yellow, and, on adding more hydro-cyanic acid, is rendered neutral, crystallizable,

and capable of resisting decomposition by weak acids. But the same compound may be better formed by digesting prussian blue in fine powder with liquid hydrate of potassa. The common prussian blue of commerce should first be heated with an equal weight of sulphuric acid, which has been diluted with five or six parts of water, and then be washed with a large quantity of distilled water. This will remove the alumine which it always contains. After being thus purified, it may be added to the hydrate of potassa, as long as that liquor continues alkaline. The filtered liquor, when evaporated and cooled, deposits crystals, which are quadrangular prisms. These may be purified by a second crystallization.

The ferro-cyanate (formerly called triple prussiate) of potassa is a transparent salt, often in fine large crystals, of a lemon-yellow colour, and free from taste and smell. Its specific gravity is 1.833. Water at 60° Fahr. dissolves nearly one-third of its weight, and boiling water nearly an equal weight. When heated, it loses 13 per cent. and becomes white, but does not run into fusion, or undergo decomposition. Submitted to a still higher temperature in a retort, it is decomposed, and yields hydro-cyanic acid and ammonia, besides carbonic acid, carbonic oxide, and carburetted hydrogen; and a residue is left, composed of charcoal, metallic iron, and potassa, which last is still united with more or less cyanogen. (See Robiquet, *Ann. de Ch. et Phys.* xvii. 205.)

Diluted acids have little action on ferro-cyanate of potassa, except with the aid of heat, and then the sulphuric, muriatic, and even the acetic acid disengage a certain quantity of hydro-cyanic acid, and occasion a white precipitate, the nature of which is not understood. Red oxide of mercury, digested with a solution of the salt, decomposes it, and gives rise to the formation of cyanide of mercury, and to the disengagement of free alkali, and of peroxide of iron attached to a little acid.

The solution of ferro-cyanate of potassa is not precipitated by alkalies, or by alkaline salts, but is decomposed by some of the earthy, and by almost all the metallic salts. The following Table by M. Thenard shows the colours of the precipitates, thrown down from various solutions, both by the ferro-cyanate, and hydro-cyanate of potassa.

Table of the Colours of Precipitates from Metallic Solutions.

From solutions of salts of	By ferro-cyanate of potassa.	By hydro-cyanate of potassa.
Manganese	White	Yellow
Iron (protoxide) . .	White	Orange.
— (deutoxide) . . .	Pale blue	Bluish-green.
— (tritoxide) . . .	Deep blue	Scarcely any.
Tin	White	White.

From solutions of salts of	By ferro-cyanate of potassa.	By hydro-cyanate of potassa.
Zinc	White	White.
Cadmium	Ditto	Ditto.
Antimony	Ditto	Ditto.
Uranium	Blood-red	Yellowish-white.
Cerium	White	
Cobalt	Grass-green	Cinnamon.
Titanium	Reddish-brown	
Bismuth	White	White.
Copper (protoxide)	Ditto	Ditto.
— (deutoxide)	Deep brown	Yellow.
Nickel	Apple-green	Yellowish-white.
Lead	White	
Mercury (deutoxide)	Ditto	Yellow.
Silver	White, changing to blue.	White, soluble in an excess of hydro-cya- nate.
Palladium	Olive	
Platinum	Yellow	
Gold	White	White, becoming yel- low.

The ferro-cyanate of potassa has been analyzed with great care by Berzelius. He decomposed it by heating it with peroxide of copper, and obtained carbonic acid and azotic gases, in the proportions in which they are evolved by the decomposition of cyanogen, viz. 2 volumes of the former and one of the latter. Hence he considers it as a cyanide, and not a prussiate, and deduces its composition to be two atoms of cyanide of potassium + 1 atom of cyanide of iron. This cyanide, in common with all those in which the metal is strongly electro-positive, as those of sodium, barium, &c. he believes to continue such, even after solution in water; while the cyanides with weaker bases, such as those of ammonia, and many of the metallic oxides, become, on the contrary, hydro-cyanates.

Mr. Porrett, on the other hand, states the composition of ferro-cyanate of potassa as follows.

Potassa	40.34	= 1 atom	} forming one atom of ferro-cyanic acid.
Iron	11.76	= $\frac{1}{2}$ ditto	
Carbon	20.17	= 4 ditto	
Azote	11.76	= 1 ditto	
Hydrogen84	= 1 ditto	
Water	15.13	= 2 ditto	

ADDITIONS TO THE CHAPTER ON SULPHUR:—SULPHURIC ACID:—SULPHATES:—BINARY COMPOUNDS OF SULPHUR.—PART. I. CHAP. XII.

Newly discovered Acids of Sulphur.—Vol. I. p. 272.

Hypo-sulphurous acid.—This acid, like the hypo-nitrous, exists only in combination with salifiable bases, forming compounds which were first examined in 1813 by Gay-Lussac, and were called by him *sulphuretted sulphites*. Beside other methods of preparing these salts, he found that they might be obtained by digesting the solution of a sulphite with sulphur, an additional quantity of which might thus be made to combine with the sulphurous acid. It had also been long ago observed by Mr. Higgins of Dublin, that liquid sulphurous acid dissolves iron without effervescence; and Berthollet afterwards showed, that, in this case, the iron is oxidized at the expense of the sulphurous acid, and that sulphur is disengaged, which immediately unites with the sulphite of iron, forming a sulphuretted sulphite. Dr. Thomson appears to have been the first who took a just view of these phenomena. The new compound he found to be a neutral salt, containing a peculiar acid of sulphur, to which he gave the name of *hypo-sulphurous acid*, and to its compounds that of *hypo-sulphites*. These compounds have been since examined with great ability by Mr. Herschell, who has not, however, succeeded completely in his attempt to exhibit the acid in a separate state; nor indeed does it appear capable of existing permanently when uncombined with a base. From the experiments of Dr. Thomson and Mr. Herschell, it may be inferred to be a compound of 1 atom of sulphur + 1 atom of oxygen, and its representative number will be $16 + 8 = 24$.

Hypo-sulphuric Acid.—This acid was discovered by Welter and Gay-Lussac. Their process for forming it consists in passing a current of sulphurous acid through water, in which finely powdered peroxide of manganese is kept mechanically suspended. There is immediately produced a perfectly neutral solution, consisting of hypo-sulphate and common sulphate of manganese. When the solution is sufficiently concentrated, pure barytes is added to the previously heated liquor, and agitated along with it, taking care to employ an excess of the earth. All the oxide of manganese is thus separated; and, sulphate of barytes being insoluble, the filtered liquor contains only the hypo-sulphate of barytes, and also the redundant portion of that earth. The latter is to be separated by a stream of carbonic acid, and subsequent ebullition to expel any excess of carbonic acid. The hypo-sulphate is then to

be crystallized, dissolved in water, and decomposed by just the quantity of sulphuric acid, which is required to precipitate the barytes. The filtered liquor is to be concentrated, by exposing it under the exhausted receiver of an air-pump along with a vessel of sulphuric acid, till it has attained the density of 1.347. If continued to be exposed, it is resolved into sulphurous acid which exhales, and sulphuric acid which remains liquid.

Oxygen gas, atmospheric air, chlorine, concentrated nitric acid, and red sulphate of manganese, are all inert on it at common temperatures. Zinc is dissolved by it, and hydrogen gas is disengaged by the decomposition of water, and there remains in solution hypo-sulphuric acid combined with oxide of zinc. It completely saturates salifiable bases, and affords neutral and soluble compounds with baryta, strontia, lime, and protoxide of lead; whereas sulphuric acid yields insoluble compounds with all those bases. At common temperatures, these salts are permanent, but, when heated, sulphurous acid escapes, and they pass to the state of sulphates, which are still neutral.

Hypo-sulphuric acid has been inferred to be composed of 100 parts of sulphur + 125 oxygen, setting apart that which is in the water essential to its existence; or we may consider it as a compound of 100 parts of sulphurous acid + 125 of sulphuric.

Composition of Alum.—Vol. I. p. 281.

Considerable differences exist in the statements which have been given by different analysts, of the composition of alum, as will appear from the following table:

100 parts contain	Acid.	Alumina.	Potassa.	Water.
According to Vauquelin	30.52 . .	10.50 . .	10.40 . .	48.58
— Dalton	33. . .	12. . .	9. . .	46.
— R. Phillips	34.94 . .	11.18 . .	10.33 . .	43.55
— Berzelius	34.23 . .	10.86 . .	9.81 . .	46.
Do. corrected by Thomson	33.82 . .	10.86 . .	9.90 . .	45.
— Dr. Thomson . . .	32.85 . .	11.99 . .	9.85 . .	46.21

Some of these differences may be accounted for by the circumstance, that in estimating the sulphuric acid, the composition of sulphate of baryta has been differently calculated. When welledulcorated, dried, and ignited, the barytic sulphate should be assumed to contain, in every 100 grains, 34 grains of real sulphuric acid.

Different views also have been taken of the state of combination in which the potassa and sulphuric acid exist in alum. Mr. R. Phillips considers the constitution of alum to be as follows, a

slight alteration of his experimental results being made to accommodate them to atomic proportions.

1 atom of bi-sulphate of potassa,
2 atoms of sulphate of alumina,
22 atoms of water.

Dr. Thomson, however, does not admit that bi-sulphate of potassa exists in alum, and contends that it is constituted of

1 atom of sulphate of potassa,
3 atoms of sulphate of alumina,
25 atoms of water.

If the number representing alumina were ascertained, it would be easy to determine which of these two views is most consistent with the atomic doctrine; but till this has been done, the subject must remain involved in some obscurity.

From indirect experiments, Sir H. Davy several years ago derived 24 as the number representing alumina, from which, deducting one atom of oxygen = 8, we obtain 16 for the equivalent of aluminum. The number for the equivalent of alumina, deduced by Gay-Lussac, is 21.611, oxygen being 10, = 17.28, when hydrogen is taken as the decimal unit. Dr. Thomson, from recent experiments, concludes it to be 2.25, oxygen being 1, = 18 when hydrogen is made unity. The former determination would reduce the atom of aluminum to 9.28, and Dr. Thomson's to 10, the atom of oxygen being considered as 8. Mr. R. Phillips is of opinion that the atom of alumina is correctly expressed by 27, and Mr. Brande (*Quarterly Journ.* xiv. 50) fixes it at 26. Differences so considerable as these sufficiently show, that we are not prepared to assign the true weight of the atom of alumina, but that the subject is still open to further investigation.

Ammoniacal alum has been examined by Riffault, who found it to consist of

1 atom of sulphate of ammonia,
3 atoms of sulphate of alumina,
24 atoms of water.

In this species of alum M. Riffault concludes that 11.906 of alumina are united with 26.979 of sulphuric acid, the remaining 9.063 of the acid being combined with 3.898 of ammonia.

In the *Quarterly Journal* (viii. 386) an alum, containing soda as its alkaline base, is described. It appears to be constituted of 51.2 water, 32.14 sulphuric acid, 10 alumina, and 6.32 soda, or of

2 atoms of sulphate of alumina,
1 atom of bi-sulphate of soda,
28 atoms of water.

In vol. xiii. p. 276 of the same journal, Dr. Ure assigns nearly the same proportions to a soda alum examined by him.

K (S)

Magnesia, also, it appears, is capable of furnishing a base to alum; but, like the last species, it has not yet been applied to any useful purpose.

The sub-sulphate of alumina and potassa has been analyzed by M. Riffault, (*Ann. de. Ch. et Phys.* xvi. 355.), and found to consist of

Sulphuric acid	35.495
Alumina	39.654
Potassa	10.021
Water	14.830

100.

This corresponds very nearly with 3 atoms of acid, 8 of alumina, 1 of potassa, and 4 of water. A native sub-sulphate of alumina has also been examined by Stromeyer, and ascertained to be composed of 30 alumina, 24 sulphuric acid, and 45 water.

Account of Several Hypo-sulphites.—Vol. I. p. 285.

Hypo-sulphite of Potassa.—This salt is best formed by exposing the hydroguretted sulphuret to the atmosphere, till it has lost its colour, after which, on evaporation, it crystallizes in the form of fine needles; or by decomposing hydro-sulphuret, or hydroguretted sulphuret of potassa by sulphurous acid. The salt has a taste, at first not unlike that of nitre, succeeded by bitterness, and it is deliquescent. When carefully dried, it takes fire on raising the heat, and burns somewhat like tinder, but with a feeble blue flame. It dissolves chloride of silver, even when very dilute, with great readiness.

Hypo-sulphite of Soda may be prepared in the same way as the analogous salt of potassa. When the solution is evaporated to a sirupy consistence, it crystallizes in silky tufts, radiating from a centre, and rendering the liquid solid. It is deliquescent, and its taste is intensely bitter and nauseous. When heated, it first fuses, then dries into a white mass, and at length takes fire and burns with a bright yellow flame. It is insoluble in alcohol. It has the property of rapidly dissolving the chloride of silver, when newly precipitated.

Hypo-sulphite of Lime.—By passing a current of sulphurous acid gas through a solution of the hydroguretted sulphuret of lime, the whole of the acid gas is converted into hypo-sulphurous acid. When this solution is boiled down to a certain degree of consistence, sulphur and sulphite of lime separate abundantly. The solution, evaporated at a temperature not exceeding 130° or at most 140° Fahr., and filtered while hot, yields, on cooling, large and very beautiful crystals, which affect a variety of complicated forms.

These crystals are *hypo-sulphite of lime*. They are very soluble in water, which at 37° Fahr. dissolves nearly its own weight, during which the thermometer falls to 31°. The specific gravity of the solution, saturated at 50°, is 1.300. The crystals are not altered by exposure to air of the usual humidity; but when dried by sulphuric acid *in vacuo*, or at 100° Fahr. in the air, they become covered with a white efflorescence, which destroys their lustre without altering their figure. They are insoluble in alcohol of sp. gr. 0.823, which precipitates them from their watery solution. By an analysis very carefully and skilfully conducted, Mr. Herschell found them to be composed of

	Atoms.
Hypo-sulphurous acid	36.71 = 2 = 48
Lime	21.71 = 1 = 28
Water	41.58 = 6 = 54
	<hr/>
	100. 130.

Or they consist (exclusive of water) of two atoms of acid united with one of base, the acid being composed of oxygen and sulphur atom to atom. (Edinburgh Phil. Journ. i. 17.) In strictness, therefore, this salt is a *bin-hyposulphite*.

Hypo-sulphite of Baryta may be obtained by adding muriate of baryta to a concentrated solution of hypo-sulphite of lime. It forms a white shining scaly powder, slightly soluble in water. According to Mr. Herschell, who alone has described it, it is a compound of 2 atoms of hypo-sulphurous acid = 48, + 1 atom of base = 78, and its equivalent number therefore is 126.

Hypo-sulphite of Strontia.—Mr. Herschell formed this salt by passing a current of sulphurous acid through hydroguretted sulphuret of strontia. It has a bitter taste; dissolves in about 1½ times its weight of water; is insoluble in alcohol; dissolves chloride of silver with great facility; and when heated *per se* becomes white, and then burns with a faint flame.

Action of Sulphuretted Hydrogen in the Lungs:—Its detection by Carbonate of Lead:—New Substance formed by its action on Sulphurous Acid:—Its Specific Gravity and Composition.—Vol. I. p. 288.

Sulphuretted Hydrogen, deleterious in the Lungs.—This gas appears to be one of the most unrespirable of all the gases; for a small bird died immediately in air containing only $\frac{1}{1000}$ of its volume of it; a dog perished in air mingled with $\frac{1}{100}$; and a horse in air containing $\frac{1}{100}$. (Thenard, i. 723.)

Method of detecting Sulphuretted Hydrogen in Mixed Gases.—By direct experiments, I have found that one measure of this gas,

mixed with 20,000 measures of hydrogen, or of carburetted hydrogen, or common air, produces a sensible discoloration of white lead, or of oxide of bismuth, mixed with water and spread upon a piece of card. In this way, we may ascertain the presence in coal gas of extremely small quantities of sulphuretted hydrogen; and may even form a tolerable estimate of its proportion, when too minute to be otherwise measured, by comparing the shade of colour, with a series that has been prepared for the purpose, by exposing slips of card covered with white lead and water to mixtures of sulphuretted hydrogen and common air in known proportions.

New body formed by the mutual action of Sulphuretted Hydrogen and Sulphurous acid.—When three volumes of sulphuretted hydrogen gas, and two volumes of sulphurous acid gas, both dry, are mixed together over mercury, they are entirely condensed into a solid body, which adheres firmly to the inside of the vessel. This substance is of an orange-yellow colour. Its taste is acid and hot, and it leaves a permanent impression on the mouth. When perfectly dry, it does not change litmus paper; but reddens it immediately when moistened. Water, alcohol, nitric acid, and sulphuric acid, decompose it, and disengage sulphur. It does not precipitate the watery solution of barytes. It is decomposed at a moderate heat, and pure sulphur remains. Dr. Thomson, who discovered this compound, considers it as an acid, and terms it *hydro-sulphurous acid*. He states it to be constituted of 5 atoms of sulphur + 4 atoms of oxygen + 3 atoms of hydrogen. (Ann. of Phil. xii. 441.)

Specific Gravity and Composition of Sulphuretted Hydrogen.—The latest attempt to ascertain its specific gravity, is that of Dr. Thomson, the result of which was 1.1788, or, more correctly, he conceives, 1.180. Hence, 100 cubic inches (bar. 30, therm. 60°) would weigh 35.89 grains. To determine its composition, therefore, we have only to subtract the specific gravity of hydrogen from that of the compound gas, and the remainder will show the weight of the sulphur. Thus,

Sp. grav. of sulphuretted hydrogen gas	1.180
— of hydrogen	0.069
	<hr/>
	1.111

It is constituted, therefore, of 1 volume of the vapour of sulphur = 1 atom (1.111) + 1 vol. of hydrogen gas = 1 atom (0.069). But the numbers 0.069 and 1.111 are in the proportion very nearly of 1 to 16, which gives exactly the same relative weight for the ultimate particle of sulphur, as that deduced from the composition of sulphuric acid.

New Acid, (the Hydroxanthic, or Carbo-sulphuric), produced by the Action of Alkalies on Bisulphuret of Carbon.—
Vol. I. p. 298.

When bisulphuret of carbon is gradually added to a solution of pure potassa, in alcohol containing 96 or 98 per cent. pure alcohol, and the mixture is agitated, the alkali is completely neutralized by the formation of a new acid. This new acid contains sulphur, carbon, and hydrogen, the two first of which probably form a compound base, analogous to cyanogen, and, like it, acidifiable by hydrogen. To the base, Mr. Zeise, Professor of Chemistry at Copenhagen, who first noticed these facts, has given the name of *xanthogen* (from *ξανθος*, yellow, and *γενναω*, to generate) on account of the yellow colour of its compounds; and to the acid that of *hydroxanthic acid*.

The neutral solution, obtained in the above manner, may be made to deposit crystals by lowering its temperature to the freezing point, or by exposing it under an exhausted receiver along with sulphuric acid. These crystals are the *hydroxanthate of potassa*. They are needle-shaped; without colour, except after exposure to the air, which renders them yellow; have a peculiar odour; a taste at first cooling, and then sharp and sulphurous; are extremely soluble in water, though not deliquescent; in a less degree in ether; and not at all in naphtha. The watery solution becomes milky when exposed to the air, and soon manifests an excess of alkali. Sulphuric or muriatic acid, diluted with four or five parts of water, and added in due quantity to the watery solution, occasions no effervescence, but causes the separation of an oily looking fluid heavier than water. This is the *hydroxanthic acid*.

Solution of baryta in water or in acids, muriate of lime, and sulphates of magnesia or alumina, do not affect the hydroxanthate of potassa; but several metallic salts occasion precipitates, which are compounds not of the metallic oxides with the new acid, but of the metals with xanthogen. Hence M. Zeise proposes to call them *xanthures*; but it is more consistent with the nomenclature followed in this work to term them *xanthides*, analogous to *chlorides*, *cyanides*, &c. Several of the xanthides are described by their discoverer.

The *hydroxanthate of potassa* is decomposed when distilled *per se*, and yields an oily fluid, with a gas which has the smell of onions, but in which nothing could be discovered but carbonic acid and sulphuretted hydrogen. At a red heat, in the open air, it takes fire, and is consumed tranquilly with a bluish flame, but in the flame of a candle, it burns actively, emitting bright sparks.

Hydroxanthates of soda and ammonia may be prepared with alcoholic solutions of those alkalies and bisulphuret of carbon; those of baryta and lime, with hydroxanthic acid and their re-

spective carbonates. The salt, with base of soda, is a little deliquescent.

Hydroxanthic acid, separated by more powerful acids from its saline compounds, with some precautions which M. Zeise has pointed out, is liquid at common temperatures, and even below them; it has the aspect of a transparent colourless oil; in specific gravity, it exceeds water; and it is not miscible with that fluid. Exposed to the air, it soon becomes covered with a white opaque crust. Its smell is powerful and peculiar. It has a taste, at first acid, then astringent and bitter; litmus paper is completely reddened by it, but a part of the paper soon changes to a yellowish-white. It is inflammable, and burns with a smell of sulphurous acid. A temperature below 212° decomposes it into bisulphuret of carbon and a combustible gas. When much divided by agitation with water, it is decomposed in a short time, giving out bubbles of gas. It expels carbonic acid from alkaline carbonates. The oxides of common metals, (copper, lead, mercury, &c.) decompose it by giving up their oxygen to the hydrogen of the acid, and the xanthogen unites with the metal, forming *xanthides*.

The presence of hydrogen in hydroxanthic acid was established by the results of acting upon it with iodine, which occasioned a distinct production of hydriodic acid, a compound of iodine and hydrogen. (*Annales de Chim. et de Phys.* xxi, 160, and *Ann. of Phil. N. S.* iv. 241.)

New Substance, produced by the Reaction of Muriatic acid and Sulphuret of Carbon on each other.—Vol. I. p. 298.

By the action of a mixture of fuming muriatic acid on sulphuret of carbon, Berzelius obtained a solid white crystalline body, resembling camphor, and possessing some remarkable properties. Its analysis afforded

Muriatic acid	48.74
Sulphurous acid	29.63
Carbonic acid (and loss)	21.63

100.

It appears, therefore, to consist of two atoms of muriatic acid, one of sulphurous acid, and one of carbonic acid.

ADDITIONS TO THE CHAPTER ON MURIATIC ACID:—OXY-
MURIATIC ACID OR CHLORINE:—AND THEIR
COMPOUNDS.—PART I. CHAP. XIV.

Combination of Chlorine and Hydrogen, forming Hydro-chloric or Muriatic Acid.—Vol. I. p. 330.

Chlorine and hydrogen gases act with considerable energy upon each other, and with different phenomena, accordingly as the experiment is conducted.

1. If a phial be entirely filled with a mixture of hydrogen and chlorine gases in equal proportions, and a well-ground stopper be introduced; no action takes place, provided light is carefully and completely excluded, even by standing some time; but on applying a lighted taper, the gases immediately explode.

2. Let a jar, guarded from the light, be half filled with chlorine gas and half with hydrogen, and a stout vessel capable of holding 4 or 6 cubical inches, and provided with a fit contrivance for passing an electric spark through it, be first exhausted by the air-pump, and then screwed upon the jar, and filled with the mixed gases. An electric spark may now be passed through the mixture, when a detonation will ensue, to avoid any injury from which the vessel should be wrapped in several folds of cloth. If the cock, attached to the vessel, be opened under mercury in about a quarter of an hour, none of that fluid will enter, proving that the volume of gas after the experiment is not diminished; but if it be removed to a vessel of water, and left there for a few minutes, the water will be found to have ascended and entirely filled the vessel. Hence a gas must have been generated by the combustion, which, though not absorbable by mercury, is condensible by water.

3. Let a stout and well stoppered phial, capable of holding three or four ounce-measures, be filled over water with equal volumes of chlorine and hydrogen gases, and a ground stopper introduced. Expose it to the ordinary day-light, guarding it from the direct rays of the sun, and in 12 or 14 hours the colour of the chlorine will have disappeared; and on withdrawing the stopper under water, the phial will be immediately filled with that fluid.

4. If the experiment be repeated, with this difference that the phial is exposed to the direct rays of the sun, the combination will take place rapidly, and a detonation will ensue, which will probably drive out the stopper. But if this should not happen, the stopper may be removed under water, which will ascend and completely fill the bottle as in experiment 3.

The agency of light may be beautifully shown by filling a tube about half an inch diameter, and 12 inches long, with the mixed gases, and alternately shading it with an opaque cover, and exposing it to the sun's rays. The moment the tube is exposed even to the diffused light of day, a cloudiness will appear within it, and the water will ascend more or less rapidly according to the intensity of the light. The effect even of a passing cloud is distinctly seen in retarding the rapidity of the combination, which is very striking in the full solar light. It is probable, that in the case of rapid union, excited by the direct rays of the sun, the combination is favoured by increase of temperature; for it has been observed by Sir H. Davy that a mixture of chlorine and hydrogen inflames at a much lower temperature than one of oxygen and hydrogen gases, and produces a more considerable degree of heat in combustion. He ascertained, also, that the former mixture will bear a much greater rarefaction than the latter, without losing its explosive property. Oxygen and hydrogen gases ceased to explode when rarefied 18 times, but chlorine and hydrogen were still combustible, when mechanically expanded to 24 times their volume.

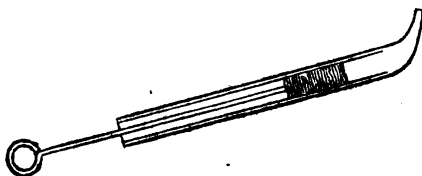
5. It had been supposed, that the direct beams of the sun were necessary to explode a mixture of chlorine and hydrogen gases; but Professor Silliman, in the *American Journal of Science* (iii. 342) has related the accidental explosion of a mixture of the gases, in the quantity that filled a Florence oil flask, not only when no direct solar light fell upon it, but when the diffuse light of day was rendered more feeble than common by a thick snow storm. This fact is important, as furnishing a caution against mixing the two gases in considerable quantities.

6. Mr. Brande found, (*Phil. Trans.* 1820), that the intense light, issuing from charcoal points connected with a powerful galvanic battery, was as effectual as solar light in acting on hydrogen and chlorine gases, and causing them to detonate; but he could not produce an analogous effect by any other terrestrial light. The moon's rays, also, he found to be quite inefficient on a mixture of these two gases.

Chloride of Nitrogen.—Vol. I. p. 341.

Mr. Brande recommends, as the simplest method of forming this compound, to fill a perfectly clean glass basin with a solution of about one part of sal ammoniac in twelve of water, and to invert into it a tall jar of chlorine gas. The saline solution gradually rises into the glass, a film forms upon its surface, and it acquires a deep yellow colour. At length small globules, resembling yellow oil, collect upon its surface, and successively fall into the basin beneath, from whence they are most conveniently removed by drawing them into a small and perfectly clean glass sy-

ringe, made of a glass tube drawn to a pointed orifice, and having a copper wire, with a little tow wrapped round it for a piston. (See the wood cut.) In this way a globule may be drawn into the tube, and transferred to any other vessel.



Messrs. Porrett, Wilson, and Kirk have published an elaborate memoir on this compound in Nicholson's Journal, xxxiv. 180, and have described at great length the appearances attending its formation, and the results of acting upon it with a great variety of substances. These experiments tend to show, that it will not explode at any temperature much under 212° Fahr. nor without the contact of a combustible body; that it may be distilled at or below 160° , and does not become solid at -16° . Though the class of bodies termed combustible act upon it most remarkably, yet there are some bodies of that description, camphor for instance, with which it seemed to unite without decomposition; nor did the metals, resins, or sugar cause it to explode. It detonated with the following only, out of 125 substances that were tried.

Supersulphuretted hydrogen.

Phosphorus.

Phosphuret of lime.

Caoutchouc.

Myrrh.

Palm oil.

Ambergris.

Whale oil.

Linseed oil.

Olive oil.

Ditto camphoretted.

Ditto sulphuretted.

Oil of tar.

Oil of amber.

Oil of petroleum.

Oil of orange peel.

Naphtha.

Metallic soaps.

Fused potash.

Solution of ammonia.

Phosphuretted hydrogen gas.

Nitrous gas.

Phosphuretted camphor.

Oil of turpentine.

Newly discovered Compounds of Carbon with Chlorine.—Vol. I. p. 343.

Per-chloride of Carbon.—Several attempts had been made to effect the combination of chlorine with carbon, by igniting charcoal in chlorine gas; but, though unsuccessful, there appeared to be no

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(S)

reason for inferring a want of affinity between those two elements, which, from other phenomena, it seemed reasonable to conclude might be rendered efficient, by bringing the two bodies into contact in a state favourable to their union. The most probable method seemed to be to employ some compound, in which carbon exists in a minute state of division, and yet not in such intimate combination, as to preclude its union with chlorine. Mr. Faraday, therefore, to whom we are indebted for a masterly set of experiments on this subject, which ended in his effecting the object in view, employed the compound of charcoal and hydrogen, usually called olefiant gas, as best adapted to the purpose. It is well known, that this gas, which is a compound of 1 atom of carbon with 1 atom of hydrogen, when mixed with an equal volume of chlorine, unites with it, and the three elements form a ternary liquid compound of chlorine, carbon and hydrogen. It is by subjecting this triple compound to the repeated action of fresh quantities of chlorine, that the hydrogen may be entirely abstracted, and a binary compound of chlorine and carbon produced.

To prepare this substance, a retort or other glass vessel of the capacity of about 200 cubic inches, provided with a brass cap and stop-cock, is first to be exhausted by the air-pump, and then made to communicate with a jar filled with chlorine. It is next to be screwed on a vessel full of olefiant gas, and as much as can find admission having entered, the cock is to be shut, and the whole left for a short time. When the fluid, composed of chlorine and olefiant gases, has formed and condensed on the sides of the vessel, the vessel is again to be placed over olefiant gas, and a further portion admitted. This process is to be repeated, till all the chlorine has united to form the fluid, and the vessel remains full of olefiant gas. Chlorine is then to be admitted by repeated portions, in consequence of which more of the fluid is formed, and ultimately a large portion is obtained, with an atmosphere of chlorine above it. The vessel is now to be exposed to the sun's rays, which cause the immediate formation of muriatic acid gas. This may be absorbed by admitting a small portion of water; and then another atmosphere of chlorine is to be introduced. Again exposed to the light, this will partly combine with the carbon, and partly form muriatic acid gas, which, being, as before, absorbed by water, leaves space for more chlorine. Repeating this action, the fluid gradually becomes thick and opaque, from the formation of crystals in it, which at last adhere to the sides of the vessel as it is turned round: and ultimately the vessel contains only chlorine, with the accumulated impurities of the gases, a strong solution of muriatic acid coloured blue by its action on the brass, and the solid substance in question.

In order to cleanse the substance, the remaining gases are first to be blown out of the vessel by a pair of bellows, and the vessel is then to be filled with water to wash away the muriatic acid and other soluble matters. The new substance is then to be detached

from the inside of the vessel, and poured with the water into a jar. A little alcohol will remove the last portions which adhere to the glass, and, when poured into the water, will precipitate the new compound, which must be collected on a filter, and dried as much as possible by pressure between folds of bibulous paper. It must next be introduced into a glass tube, and sublimed by a spirit lamp. A part will be decomposed, but the sublimed portion is to be dissolved in alcohol, and poured into a weak solution of potash, by which the new substance is thrown down, and the muriatic acid neutralized and separated. Then wash away the potash and muriate by repeated affusions of water, until the substance remains pure; collect it on a filter, and dry it, first by pressure between folds of paper, and afterwards by sulphuric acid under the exhausted receiver of an air-pump. It will now appear as a white pulverulent substance; and, if perfectly pure, will not, when a little is sublimed in a tube, leave the slightest trace of carbon, or afford any muriatic acid. A small portion, dissolved in ether, should give no precipitate with nitrate of silver. If not quite pure, it must be re-sublimed, washed, and dried, as often as is necessary.

To this compound, Mr. Faraday has given the name of *perchloride of carbon*. When pure, it is, immediately after fusion, a transparent colourless substance, having scarcely any taste. Its odour is aromatic, and approaches that of camphor. Its specific gravity is as nearly as possible 2. Its refractive power is high, being above that of flint glass (1.5767.) It is very friable, easily breaking down on pressure, and when scratched, has much of the feel and appearance of white sugar. It does not conduct electricity. It is crystallizable, and the varieties of its form, which are very numerous and interesting, result from a primitive octohedron.

It volatilizes slowly at common temperatures, and, like camphor, passes towards the light. At 320° Fahr., it fuses, and boils at 360°. When condensed from these rapid sublimations, it is in so transparent and colourless a state, that it is difficult to perceive where it is lodged.

It is not readily combustible. When held in the flame of a spirit lamp, it burns with a red flame, emitting much smoke and acid fumes; but when removed from the lamp, combustion ceases. In an atmosphere of pure oxygen, it burns with a brilliant light.

It is very sparingly soluble in water, either hot or cold; but dissolves readily in alcohol, especially if heated. The solution is decomposed when poured into water, and gives regular crystals on cooling or evaporation; but does not, with nitrate of silver, form the chloride of that metal. Ether, particularly when heated, dissolves it, even more readily than alcohol. It is soluble also in volatile oils, and in fixed oils; but the latter solutions assume a charred appearance when heated.

It is not changed by solutions of pure alkalies, even when ap-

plied boiling hot; nor is it attacked by concentrated and heated muriatic, nitric, or sulphuric acids.

When transmitted in vapour mixed with oxygen gas through a red-hot tube, there is a decomposition, and mixtures of chlorine, carbonic acid, carbonic oxide, and chloro-carbonic acid are evolved. It is decomposed also by peroxide of mercury with the aid of heat.

Chlorine has no action on it. Iodine either unites with it, or at high temperatures takes away a portion of chlorine. Hydrogen gas, when transmitted along with it through red-hot tubes, decomposes it, and muriatic acid and charcoal are produced.

Sulphur, at moderate temperatures, unites with it; at higher ones, removes one portion of chlorine. The same effect is produced by phosphorus. Charcoal is quite inefficient on it. Most of the metals decompose it with the aid of heat, forming chlorides, and charcoal being liberated. Peroxides produce with it, at a high temperature, chlorides and carbonic acid; protoxides afford chlorides and carbonic oxide.

In forming this substance, Mr. Faraday believes that five volumes of chlorine gas saturate one of olefiant, and produce four volumes of muriatic acid gas; that three volumes of the chlorine combine with the two volumes of charcoal existing in the olefiant gas to form the crystalline solid; and that when chlorine acts on the fluid compound of chlorine and olefiant gas, for every volume of chlorine that combines, an equal volume of hydrogen is separated. The results of its decomposition by peroxide of copper, confirm these views, and tend to establish that the composition of this per-chloride is

3 atoms of chlorine	= 108
2 ditto of carbon	= 12
<hr/>	
Weight of its atom	120

Proto-chloride of Carbon.—By passing the vapour of per-chloride of carbon over fragments of rock crystal ignited in a glass tube, the upper part of which is bent up and down two or three times, so that the angles may form receivers for the new compound, a partial decomposition is effected; one portion of chlorine is separated and escapes; and the remainder, continuing united to the carbon, forms a fluid substance, which may be collected and purified by repeated distillations. This is the *proto-chloride of carbon*.

It is a highly limpid and perfectly colourless fluid; its specific gravity is 1.5526; it is a non-conductor of electricity; its refractive power is 1.4875, being very nearly that of camphor. It is not combustible, except when held in the flame of a spirit lamp, and then it burns with a bright yellow light, much smoke, and fumes of muriatic acid.

It does not become solid at 0° Fahr. When its temperature is raised under the surface of water to between 160° and 170° , it is converted into vapour, and remains in that state till the temperature is lowered. When its vapour is passed over ignited fragments of rock crystal, it undergoes a partial decomposition.

It is not miscible with water, but is soluble in alcohol, ether, and fixed and volatile oils. Neither alkaline solutions nor strong acids produce any effect upon it. It is not decomposed by solutions of silver. Oxygen gas, at high temperatures, forms with it carbonic oxide, and chlorine is liberated. Hydrogen, under the same circumstances, forms muriatic acid with its chlorine, and charcoal appears. The metals, at high degrees of heat, absorb the chlorine, and liberate charcoal; oxides, according to their proportion of oxygen, form with it either carbonic acid or carbonic oxide.

By analysis, effected by peroxide of copper, it is shown to be constituted of

1 atom of chlorine	36
1 ditto of carbon	6

Weight of its atom 42

Sub-chloride of Carbon.—A third compound of chlorine and carbon was brought over from Sweden by M. Julin, of Abo, where it had been accidentally formed during the distillation of nitric acid from crude nitre and sulphate of iron. The quantity produced at each process did not exceed a few grains, which condensed in fine white feathery crystals in a glass tube, connecting the first and second receiver. Its properties are described by M. Julin as follows: (Ann. of Phil. N. S. i. 216.)

It is white; consists of small soft adhesive fibres; sinks slowly in water; is insoluble in it, whether hot or cold; is tasteless; has a peculiar smell, somewhat resembling spermaceti; is not acted upon by concentrated and boiling acids or alkalies, except that some of them dissolve a small portion of sulphur; dissolves in hot oil of turpentine and in alcohol, but most of it crystallizes in needles on cooling; burns in the flame of a lamp with a greenish-blue flame, and a slight smell of chlorine; when heated, melts, boils, and sublimates between 350° and 450° Fahr., or sublimates slowly at a heat of 250° , forming long needles. Potassium burns with a vivid flame in its vapour, and charcoal is deposited; and a solution of the residuum in nitric acid gives a copious precipitate with nitrate of silver.

A small quantity of this substance, having been put into the hands of Messrs. R. Phillips and Faraday, has been made by them the subject of analysis. They found that it might readily be purified from sulphur by boiling in liquid potash, washing in water, drying, and subliming, when it formed beautiful acicular crystals, in the form of four-sided prisms.

It was decomposed into chlorine and charcoal by being passed over red-hot fragments of rock crystal. Its vapour, being detonated over mercury with excess of oxygen, gave carbonic acid gas and chloride of mercury. When heated with phosphorus, iron, or tin, chlorides of those substances were formed, and charcoal deposited. Its analysis was effected in two ways; by being transmitted over ignited peroxide of copper, and over dry quick-lime. Both processes gave results which conspire to show that it is constituted of

1 atom of chlorine	36
2 atoms of carbon	12
	<hr/>
Weight of its atom	48

Messrs. Phillips and Faraday have not given any name to this compound. It may be called, provisionally, the sub-chloride of carbon.

Thus we have three distinct compounds of chlorine and carbon, viz.

	At. of Chlor.	At. of Carb.
The per-chloride	3	+ 2
The proto-chloride	1	+ 1
The sub-chloride	1	+ 2

It is probable that another chloride of carbon will hereafter be found, consisting of two atoms of chlorine and one of carbon.

Chloride of Potassium and Muriate of Potassa.—Vol. I. p. 347.

When chloride of potassium is dissolved in water, a double elective affinity is supposed to operate; water is decomposed; its hydrogen, uniting with the chlorine, composes muriatic acid; and the oxygen of the water, being transferred to the potassium, constitutes potassa. The acid and alkali together form muriate of potassa. By evaporating the solution, crystals are again obtained of chloride of potassium.

Considered as muriate of potassa, (in which state this salt must always exist when in watery solution), it may be regarded as constituted of an atom of muriatic acid 37, and an atom of potassa 48, and its representative number is 85. Under this view, it is constituted of

Acid	36.57
Potassa	63.43
	<hr/>

100.

Preparation and Composition of Muriate of Ammonia.—Vol. I. p. 349.

The common sal ammoniac of the shops is prepared by a circuitous process from an impure carbonate of ammonia, obtained by the distillation of bones, and other animal matters. This carbonate of ammonia, by being kept in contact with sulphate of lime and water, is converted into sulphate of ammonia. This again is decomposed by muriate of soda, which affords muriate of ammonia and sulphate of soda. The latter salt is separated by priority of crystallization, and the muriate of ammonia is then purified by being once or twice sublimed.

It has lately been ascertained by Dr. Marcet, that muriate of ammonia exists in sea water, and may be separated by sublimation from the uncrystallizable part called *bittern*.

It is easy to calculate the composition of this salt; for since 100 cubic inches of muriatic acid gas weigh 39 grains, and the same volume of ammonia weighs 18.18 grains, muriate of ammonia must consist of

		Atom.	
Muriatic acid	. . 68.205	. . 1	. . 37
Ammonia	. . . 31.795	. . 1	. . 17
	<hr/> 100.		<hr/> 54

Action of Chlorine on Ammonia.—Vol. I. p. 358.

Scheele first observed, that, when liquid solutions of chlorine and ammonia are mixed, or when æriform chlorine is passed through liquid ammonia, nitrogen gas is disengaged, and muriatic acid formed. In this case the hydrogen of the ammonia unites with the chlorine, and the nitrogen is liberated. The latter process furnishes a good method of obtaining nitrogen gas.

Chloride of Lime, or Bleaching Powder.—*Chloride of Magnesia.*—Vol. I. p. 360.

Chloride of Lime.—When chlorine gas is brought into contact with proto-hydrate of lime, which has been passed through a fine sieve, the gas is absorbed with rapidity, and with the evolution of much heat. It is necessary, indeed, either to pass the current of gas very slowly, or to surround the vessel containing the lime with

cold water, and occasionally also to change the surface of the lime by stirring it. When the hydrate has taken all the gas that it is capable of absorbing there remains a dry white powder, of considerable importance, from its extensive use in the art of bleaching, and known in commerce by the names of *bleaching powder*, or *oxymuriate of lime*.

This substance, to which the name of *sub-chloride of lime*, or *sub-chloride of hydrated lime*, is more appropriate, has a faint odour of chlorine, and a penetrating taste. When agitated with water, a portion is dissolved, varying in different specimens. The solution of a sort of fair commercial quality, when a wine-gallon of water had been made to act upon a pound of the salt, I found had the specific gravity of 1.035. A large residue of undissolved matter is always left, which consists for the most part of hydrate of lime, not entirely free, however, from chlorine, the smell of which is evolved from it on adding an acid. The solution in water always contains an excess of lime, and does not actively discharge vegetable colours, till some acid is added to disengage the lime from the chlorine.

Chloride of lime exposed to heat is decomposed; a small portion of chlorine gas and some water first come over; and on raising the heat to upwards of 600° , oxygen gas is evolved, by the action of the chlorine upon the calcium, which is the base of the lime. For every 50 cubic inches of oxygen that are obtained, we may reckon that 100 cubic inches of chlorine ($= 76\frac{1}{4}$ grains) have united with the calcium. The chloride of lime is thus converted by heat into chloride of calcium. A similar change appears to take place by long keeping at ordinary temperatures; for the salt gradually loses its bleaching power. When fresh prepared, it does not essentially contain any chloride of calcium, or muriate of lime; but in a specimen which had been kept about five years, Mr. Dalton found 30 per cent. of that salt, the chloride of lime being proportionally diminished.

The composition of sub-chloride of lime was first attentively examined by Mr. Dalton. A specimen formed by exposing the proto-hydrate of lime to chlorine gas, till it would absorb no more, he found to be constituted of

Chlorine	23
Lime	38
Water	39

100

These numbers, indeed, do not exactly agree with any atomic proportions; but if altered a little, as follows, to correct defects in the analysis, which are within the limits of possible error, the constitution of the salt would cease to be anomalous; viz.

Chlorine . . .	24.36 . .	= 1 atom . .	36
Lime . . .	38.54 . .	= 2 atoms . .	56
Water . . .	37.10 . .	= 6 atoms . .	54
<hr/>			<hr/>
100.			146

Each atom of lime appears, therefore, to have been united with 3 atoms of water, or to have been in the state of trihydrate. These proportions of chlorine and lime are such as to constitute a true *sub-chloride*, as Mr. Dalton names it; or *sub-bichloride*, as it has been called by Dr. Thomson.

When water was made to act upon the sub-chloride, Mr. Dalton found that one-half of the whole lime was deposited. The atom of chlorine, therefore, was, in the solution, engaged by an atom of base, constituting a true *chloride of lime*. This compound is probably not capable of existing long in solution; for when the liquid is boiled to dryness, chloride of calcium is the product, giving muriate of lime by solution in water.

In this view of the constitution of chloride of lime, Dr. Thomson and M. Welter for the most part agree; except that they assign, to the dry salt, proportions of water differing from those of Mr. Dalton. Both of them admit that a partition of the base is effected by solution, and that, in the liquid, the existing compound contains an atom of each of its elements.

The assay of sub-chloride of lime, in order to ascertain its commercial value, has been effected in several ways. Mr. Dalton first proposed detaching the gas from a given weight either of the dry or liquid compound, over mercury in a graduated tube, by means of an acid. A portion of the chlorine is retained by the liquid, which may be estimated at twice its volume; but no sensible error is, it seems, occasioned by the action of the chlorine on the mercury. He afterwards announced what he considers as an improved method, viz. the successive addition of a solution of the chloride to a solution of green sulphate of iron (sp. gr. 1.149) till the smell of chlorine is developed. This method, however, I consider as greatly inferior to that of liberating the chlorine by an acid. To effect this, without the aid of a mercurial trough, Dr. Ure has contrived an instrument described in the Quarterly Journal, xiii. 21. For the purposes of the artist, I believe, however, the most practicable method will be found to be the test of solution of indigo in sulphuric acid. It may be of such strength that 1600 parts of the liquor contain one of indigo. Of this solution, 100 cubic inches of chlorine = $76\frac{1}{2}$ grains, destroy the colour of 1159.5 cubic inches, or 10 grains of chlorine discharge the colour of 152 cubic inches of the solution. It is desirable to dilute the solution of chloride, so that its volume may be nearly one-half that of the colour test; to pour the former into the latter slowly and at intervals, stirring the mixture well after each addition; and in making several comparative experiments, to take care that the quality

of the test, and the manner of proceeding, shall be the same in all. It cannot, however, be pretended that this test possesses the scientific accuracy attainable by the admeasurement of the disengaged chlorine, which alone is to be depended upon, when a precise analysis is required.

Chloride of Magnesia.—This chloride may be prepared by passing chlorine gas into water, in which magnesia is kept mechanically suspended, or by the mixture of solutions of chloride of lime and sulphate of magnesia. It has not yet been accurately investigated. It is of use in some of the processes of bleaching.

**ADDITIONS TO THE CHAPTER ON PHOSPHORUS:—PHOS-
PHORIC ACID:—PHOSPHOROUS ACID:—PHOS-
PHATES.—PART. I. CHAP. XV.**

Additional Observations on Phosphorus.—Vol. II. p. 1.

Discovery of Phosphorus.—Phosphorus was discovered about the year 1669 by Brandt, an alchemist of Hamburgh, while employed in the research after the art of converting the baser metals into gold and silver; and afterwards by Kunckel, a German chemist. But the method of preparing it was not publicly divulged by either of those persons; and it was not till 1737, that a commission, appointed by the French Academy of Sciences, was instructed by a stranger in the process. It consisted in evaporating putrid urine to dryness, and distilling the residuum at an intense heat in a stoneware retort. Margraff improved the process by adding a salt of lead to the urine, and in 1769, Gahn, of Sweden, having discovered the phosphoric acid in bones, invented the method of preparing phosphorus which is now generally followed.

Action of Heat.—Phosphorus melts at about 109° or 110° Fahr., [and not at 90° Fahr., as stated in the body of the work.] Exposed to a heat of between 140° and 160° Fahr. and suddenly cooled, it becomes black; but, if slowly congealed, it remains transparent and colourless: when cooled at a moderate rate, it assumes the semi-transparency of horn. According to Thenard, however, it is not all phosphorus that exhibits these properties, but only that which has undergone repeated distillations.

Action of Oxygen, either rarefied, or diluted with other Gases.—If a cylinder of phosphorus be introduced into a vessel of oxygen gas over mercury, at a temperature not exceeding 80° Fahr., no perceptible absorption will happen in 24 hours; but if, the tempe-

perature remaining the same, the pressure be diminished to $\frac{1}{4}$ th or $\frac{1}{10}$ th that of the atmosphere, the phosphorus will be surrounded by white vapours, will become luminous in the dark, and will absorb oxygen. Under ordinary pressures, a higher temperature is required to produce this effect; but it is remarkable, that if the density of the oxygen be reduced in the above proportion, by mixing it with azote, hydrogen, or carbonic acid, the phosphorus becomes luminous. Hence phosphorus absorbs oxygen from atmospheric air with an extrication of light.

Oxides of Phosphorus.—Phosphorus, kept under water in a bottle partly filled with that fluid, and into which fresh air is occasionally admitted, becomes slowly oxygenized, partly into a soluble compound which the water takes up, and partly into a white substance that invests the sticks of phosphorus with an insoluble crust. This appears to be an oxide of phosphorus.

When phosphorus is burned in a quantity of atmospheric air much short of that which is required to consume it, the unburned portion consists of a red oxide, mixed with unconsumed phosphorus and phosphoric acid. The red substance is an oxide of phosphorus, but neither the precise composition of this nor of the white oxide has been yet ascertained. It has been conjectured, indeed, that the white compound is a *hydrate*, composed of water united with the red oxide.

Account of Several Phosphates.—Vol. II. p. 6.

Phosphate of Potassa is a salt which is neutral only when in solution, for, on attempting to crystallize it, an acid salt separates, and there remains an uncrystallizable *magma*, with an excess of alkali.

This phosphate has little taste. By the action of heat, it undergoes the igneous fusion. It is not decomposed by lime, unless when the lime is added in considerable excess, and then a compound is formed of phosphoric acid with potassa and lime. The vegetable grains belonging to the *cereal*ia contain a small quantity of this salt. It is believed to be a compound of 1 atom of phosphoric acid + 1 atom of potassa.

Sub-phosphate of Potassa may be obtained by evaporating the uncrystallizable portion of the foregoing solution, or by fusing phosphate and hydrate of potassa together in a platinum crucible. It is insoluble in cold, and very sparingly soluble in hot water. It is probably constituted of 2 atoms of potassa, and 1 atom of acid.

Bi-phosphate of Potassa has been very little examined. All that is known is, that, of the compounds of potassa with phosphoric acid, this is the only one which is susceptible of crystallization.

Phosphate of Strontia may be formed, by mixing solutions of muriate of strontia and phosphate of soda. It is tasteless, insoluble in water, but soluble in an excess of phosphoric acid; fusible by the blow-pipe into a white enamel; and decomposable only by sulphuric acid. It consists, according to Stromeyer, of

Acid	36.565
Base	63.435

100.

If a true binary compound, it should consist of very nearly 65 base + 35 acid.

Phosphate of Magnesia may be formed either directly by dissolving carbonate of magnesia in phosphoric acid, or by mixing solutions of sulphate of magnesia and phosphate of soda. No immediate change ensues, but, after a few hours, large transparent crystals of phosphate of magnesia make their appearance in the solution. The crystals require 15 parts of cold water, but a smaller proportion of boiling water, for solution. They effloresce in the air, and, when heated, leave a dry powder, which is fusible into a transparent glass.

Ammonia-phosphate of Magnesia may be prepared by mixing solutions of phosphate of ammonia and phosphate of magnesia, or any other soluble salt with base of that earth. It falls down in the form of a white insoluble powder; but, in certain varieties of urinary calculi, it is found lining cavities of the concretions, in a distinctly crystallized form, and it is deposited in crystals on the sides of vessels, in which urine is long kept. It is tasteless, scarcely soluble in water, readily soluble in dilute acids, and is decomposed by heat, leaving phosphate of magnesia only. According to Fourcroy, it contains equal weights of phosphate of ammonia, phosphate of magnesia, and water.

Phosphate of Lime derives importance from its being the principal ingredient of animal bones, of which it constitutes about 86 per cent. It may be obtained by dissolving bones, which have been well calcined and then pulverized, in dilute muriatic acid, and precipitating the solution with pure ammonia. The precipitate, when sufficientlyedulcorated, is *phosphate of lime*, an insipid white powder, insoluble in water, but soluble in diluted nitric, muriatic, and acetic acids, and again precipitable, unaltered, from those acids by caustic ammonia. At a high temperature, it fuses into an opaque white enamel. It is constituted, according to Mr. Dalton's experiments, of 49 acid + 51 lime, proportions which authorize us to consider phosphate of lime as consisting of 1 atom of acid = 28, + 1 atom of base = 28, the compound atom being 56.

Bi-phosphate of Lime may be formed by digesting phosphate of

lime with a quantity of phosphoric acid equivalent to that already engaged in the salt. The solution has an acid, and somewhat harsh and disagreeable taste. It does not crystallize, but forms, when evaporated, a white mass, which attracts moisture from the air. Before the blow-pipe, it melts into a transparent glass, insoluble in water.

Tri-phosphate of Lime.—This salt, according to Mr. Dalton, may be formed by adding pure phosphoric acid to lime-water, till a commencement of precipitation appears, when the solution must be cleared by a drop or two of acid. If the solution be evaporated to dryness at a moderate heat, and then dissolved in water again, simple phosphate of lime remains, and a quadri-phosphate exists in the solution.

Quadri-phosphate of Lime.—If 100 parts of phosphate of lime be digested for 24 hours with 87 parts of sulphuric acid, diluted with a sufficient quantity of water, and be then filtered, the liquid which passes through contains the whole of the phosphoric acid, with only one-fourth of the lime which existed in the original salt, the remaining $\frac{3}{4}$ ths having formed an insoluble compound with the sulphuric acid. The dissolved salt is, therefore, a compound of 1 atom of lime = 28, + 4 atoms of acid = 112. When evaporated, it forms, on cooling, pearly scales, which have an acid taste, and dissolve readily in water, giving a solution of the sp. gr. 1.44. When dried and fused in a crucible, a transparent glass is obtained, commonly called *glacial phosphoric acid*, and employed chiefly in the production of phosphorus.

Octo-phosphate of Lime.—Mr. Dalton is of opinion that a compound of 8 atoms of acid and 1 atom of lime is the true result of the process described under the last head; and that a compound of as many as 12 atoms of acid with 1 of lime may exist, forming a *dodecaphosphate*.

ADDITION TO THE CHAPTER ON BORACIC ACID.—PART I. CHAP. XVI.

Process of Gay-Lussac and Thenard for obtaining Boron:— Its Properties and Composition.—Vol. II. p. 17.

Boron was first obtained by Sir H. Davy, in 1808, by the action of Voltaic electricity on boracic acid. The same substance was afterwards obtained more abundantly by Gay-Lussac and Thenard, by the action of potassium. Equal parts of potassium and

very pure and vitreous boracic acid were put into a copper tube, which was gradually heated to redness. At the temperature of 302° Fahr., the mixture became suddenly red, and the metal disappeared by acting on the boracic acid. By washing the residuum with warm water, a greenish-brown or olive substance was obtained, which is the base or radical of boracic acid.

This substance is insoluble in water, it is destitute of taste, and does not affect vegetable blue colours. Mixed with chlorate or nitrate of potash, and projected into a red-hot crucible, it burns vividly, and boracic acid is reproduced. In close vessels it may be exposed to a strong heat, without undergoing any change except an increase of density, for it now sinks in sulphuric acid of sp. gr. 1.844. It is a non-conductor of electricity.

When heated to 600° Fahr. in the open air, it burns vividly, absorbs oxygen, and affords boracic acid; but the coating, which it acquires of that acid, soon stops the combustion. The quantity of oxygen absorbed by a given weight has been investigated by Gay-Lussac and Thenard, and by Sir H. Davy. According to the latter, 100 parts of boron absorb 174 of oxygen. Berzelius investigated the same problem indirectly, and was led to conclude that 100 of boron unite with 300 of oxygen to form boracic acid. Dr. Thomson, after pursuing the same inquiry by different means, infers that 100 grains of boron condense 266.6 grains of oxygen, which are in the proportions of 6 to 16, indicating that the composition of boracic acid agrees exactly with that of the carbonic, as to the relative proportions of base and oxygen. According to this view, the atom of boron weighs 6; and each atom, to form boracic acid, combines with two atoms of oxygen, ($8 \times 2 = 16$), and the atom of acid weighs 22. These results, however, are still liable to considerable uncertainty.

ADDITION TO THE CHAPTER ON FLUORIC ACID.—PART I. CHAP. XVII.

Fluate of Lime.—Vol. II. p. 19.

There is a natural product, well known in Derbyshire, and other parts of the world, under the name of *fluor spar*, which is worked into a variety of ornaments. It most commonly, when crystallized, occurs in cubes, but its primitive form is an octohedron. Its specific gravity is 3.15. It is perfectly tasteless and insoluble in water. When thrown in powder upon a plate of iron heated below redness in a dark place, it emits a phosphorescent light.

Concentrated sulphuric acid occasions an effervescence by expelling fluoric acid gas. Berzelius considers it as a compound of 100 fluoric acid + 258.9 lime. In strictness, however, it is to be regarded as a *fluoride of calcium*, and its composition is probably 100 fluorine + 131.25 calcium.

ADDITION TO THE CHAPTER ON IODINE AND ITS COMPOUNDS.—PART I. CHAP. XVIII.

Iodates and Hydriodates.—Vol. II. p. 25.

Iodate of Ammonia.—This salt is best formed by saturating iodic acid with ammonia. It is deposited in small crystalline grains of an indeterminate form. When these are thrown on a red-hot coal, they detonate with a feeble violet flame and an escape of iodine. When heated in close tubes, the tubes are frequently burst; but Gay-Lussac succeeded in collecting the products, which were equal volumes of oxygen and azotic gases. He states its composition at 100 acid + 10.94 ammonia, or 2 vols. of gaseous ammonia, 1 volume of iodine in vapour, and $2\frac{1}{2}$ volumes of oxygen.

Hydriodate of Ammonia is constituted of equal volumes of hydriodic acid gas and ammoniacal gas. It may be formed by mixing the watery solutions of the acid and base. It crystallizes in cubes, which are more soluble than sal ammoniac, and nearly as volatile, subliming in close vessels without decomposition.

Iodate and Hydriodate of Potassa.—Both these salts are formed by agitating iodine with a solution of potassa; water is decomposed, and gives origin to a very soluble hydriodate and a difficultly soluble iodate. The latter may be purified by being washed, first with a little water, and afterwards with alcohol sp. gr. .820, which removes the hydriodate. The iodate remains in small white and granular crystals.

When projected on red-hot coals, iodate of potassa burns like saltpetre; 100 parts heated in a retort give 22.59 oxygen gas, and 77.41 iodide of potassium. It requires for solution $13\frac{1}{4}$ parts of water at 60° Fahr. It is constituted of 22.246 potassa and 77.754 iodic acid.

Hydriodate of potassa is deliquescent, and consequently very soluble. It is constituted of 100 hydriodic acid + 37.426 potassa. By crystallization, or simple desiccation, it is changed into iodide of potassium, which is easily fused and volatilized without change at a red heat.

Iodate and Hydriodate of Soda.—Both these salts are obtained by agitating iodine with liquid hydrate of soda. The iodate has the form of small grains, which have a cubical shape, contain no water of crystallization, and when heated yield oxygen gas, a little iodine, and an iodide of sodium. They contain 84.1 iodic acid and 15.9 soda.

Hydriodate of soda crystallizes in flattened rhomboidal prisms, which are deliquescent, and contain much water of crystallization. By a sufficient heat, it is converted into iodide of sodium: of this iodide, 100 parts of water at 60° Fahr. dissolve 173 parts, and, when strongly heated, it becomes slightly alkaline, and is volatilized. The hydriodate of soda is composed of 100 parts hydriodic acid, and 24.728 soda.

Iodate of Lime requires for solution several hundred times its weight of water. When exposed to a strong heat, it is decomposed, oxygen and iodine are given off, and the base remains.

Hydriodate of Lime is deliquescent, crystallizable, enters into fusion at a heat a little below redness, and is converted into iodide of calcium in close vessels; but when heated with the free access of air, much of the iodine is separated, and a sub-iodide of calcium remains.

Iodide of Barium may be formed by evaporating and igniting the hydriodate of baryta. The hydrogen of the acid unites with the oxygen of the earth, and the iodine with its metallic base.

Hydriodate of Baryta is extremely soluble in water, and rather deliquescent. It crystallizes in very small prisms, which are decomposed by mere exposure to the atmosphere into water, a salt with excess of iodine, and carbonate of baryta. When ignited in close vessels, it is converted into iodide of barium. It is constituted of 100 acid + 60.62 baryta.

Iodate of Baryta is an extremely insoluble salt. It may be formed by adding iodine to solution of baryta, from which the iodate precipitates in the state of a white powder, and may be edulcorated by washing with distilled water. When strongly heated, oxygen and iodine are evolved from it, and baryta remains. It consists of 100 acid + 46.34 base.

Hydriodate of Strontia is extremely soluble, and crystallizes in very slender prisms. Heated a little below redness in a close vessel, it is transformed into *iodide of strontium*.

Iodate of Strontia is an insoluble compound, requiring some hundred parts of water for solution. At a red heat, it is decomposed into oxygen, iodine, and strontia.

ADDITIONS TO THE CHAPTER ON METALS,—PART. I.
CHAP. XIX.

*Table of the Specific Gravities of Metals; Water, at 60° Fahr.,
being 1.—Vol. II. p. 30.*

			Authority.
Platinum	- - -	20.98	Brisson.
Gold	- - -	19.257	Ditto.
Tungsten	- - -	17.6	D'Elhuyart.
Mercury	- - -	13.568	Brisson.
Palladium	- - -	11.3 to 11.8	Wollaston.
Lead	- - -	11.352	Brisson.
Silver	- - -	10.474	Ditto.
Bismuth	- - -	9.822	Ditto.
Uranium	- - -	9.000	Bucholz.
Copper	- - -	8.895	Hatchett.
Cadmium	- - -	8.604	Stromeyer.
Cobalt	- - -	8.538	Haüy.
Arsenic	- - -	8.308	Bergmann.
Nickel	- - -	8.279	Richter.
Iron	- - -	7.788	Brisson.
Molybdenum	- - -	7.400	Hielm.
Tin	- - -	7.291	Brisson.
Zinc	- - -	6.861 to 7.1	Ditto.
Manganese	- - -	6.850	Bergmann.
Antimony	- - -	6.702	Brisson.
Tellurium	- - -	6.115	Klaproth.
Sodium	- - -	0.972	{ Gay-Lussac & Thenard.
Potassium	- - -	0.865	

Fusibility and Structure of Metals.—Vol. II. p. 31.

THE metals are all *fusible*, provided a due degree of heat be applied, which, for some, is very moderate, and for others extremely intense. Mercury is the only metal that exists constantly in a fluid state at the temperature of our climate. Potassium, sodium, tin, bismuth, lead, tellurium, arsenic, zinc, antimony, and cadmium, all melt at a temperature below that of visible redness, and in the order set down, the most fusible being placed first. Silver, copper, gold, cobalt, iron, manganese, nickel, and palladium, all require a red heat. Molybdenum, uranium, tungsten, and chromium,

are almost infusible, and cannot be obtained by the heat of a forge in compact buttons, but fuse under the oxygen and hydrogen blow-pipe. Titanium, cerium, osmium, iridium, rhodium, platinum, and columbium are infusible by the forge, but yield to the powers of the oxygen and hydrogen blow-pipe.

The *structure or texture* of several of the metals appears to be *crystalline*. That of iron, developed by the action of solvents, has been shown by Mr. Daniel to be fibrous. Bismuth and antimony have a lamellated texture; nickel presents a fracture between fibrous and foliated; and steel is granular. Several of the metals, when melted and cooled under favourable circumstances, form regular crystals. Thus bismuth, melted in a crucible, and suffered to cool, becomes covered with a crust, and when this is pierced, and the fluid beneath allowed to flow out, the cavity is found studded with beautifully regular cubic crystals. Arsenic crystallizes in regular tetrahedrons, and titanium in long slender filaments or prisms.

Metallic Sulphurets.—Vol. II. p. 44.

WHEN metallic oxides, including under that name the fixed alkalies and earths, are heated with sulphur, it appears, that part of the sulphur unites with the oxygen of the oxide, and the remainder with the metallic base. The same combination is effected by igniting the sulphates in contact with charcoal, especially in a manner lately pointed out by Berthier, which avoids the uncertainty arising from an excess of charcoal. He places the sulphates in the centre of a crucible, thickly lined with charcoal, and after covering them with charcoal, and luting on a cover, heats the whole in a furnace. In this way, the sulphates are reduced as it were by cementation, the time required being proportionate to the temperature, the fusibility of the sulphurets, and the quantity of materials operated upon. In this way, not only are pure sulphurets obtained, but the result may be collected without the smallest loss, its weight ascertained, and the weight of oxygen evolved, accurately estimated. (Quart. Journ. xv.)

The sulphates of baryta, strontia, and lime sustain a loss exactly equivalent to the oxygen contained in the acid and base. When the sulphurets, thus formed, are dissolved in muriatic acid, nothing is disengaged but pure sulphuretted hydrogen gas, no sulphur is liberated, nor is any acid containing sulphur and oxygen formed. The sulphurets, then, contain no oxygen, and the base is in the metallic state.

The following table exhibits the composition of some of the sulphurets, as determined by Berthier. In the last column, I have

stated the theoretical composition, assuming the equivalents annexed to the metals to be correct:

	Equiva- lent of Metal.	From Experiment. Metal.	Sulphur.	From Theory. Metal.	Sulphur.
Sulphuret of Barium . . .	70 . . .	100 +	24.47 . . .	100 +	22.85
Strontium . . .	44 . . .	100 +	36.60 . . .	100 +	36.36
Calcium . . .	20 . . .	100 +	78.30 . . .	100 +	80.00
Potassium . . .	40 . . .	100 +	41.06 . . .	100 +	40.00
Sodium . . .	24 . . .	100 +	69.27 . . .	100 +	66.66
Zinc . . .	33 . . .	100 +	50.00 . . .	100 +	48.48
Manganese . . .	28 . . .	100 +	56.32 . . .	100 +	57.14

Composition of Metallic Chlorides.—Vol. II. p. 47.

THE compounds of chlorine with metals have been ably investigated by Dr. John Davy, and it is chiefly his results that have furnished materials for the following Table, in which the equivalent of chlorine is taken at 36. The first column contains the name of the chloride; the second, the equivalent of the metal deduced from its oxide or from some other compound; the third, the proportion of chlorine; and the fourth, the equivalent of the metal, deduced from the lowest proportion, in which it has actually been found to unite with chlorine. In most instances, the numbers in the first and last columns will be found very nearly to coincide. When the difference is trifling, it may be imputed to errors unavoidable in analyses of this kind; but when very considerable, as in the case of arsenic, the disagreement shows the necessity of more accurate experiments either on the oxide, the chloride, or on both.

Table of the Principal Compounds of Metals with Chlorine.

Name of chloride.	Equiv. of metal.	Proportion of chlorine.	Equiv. of metal deduced from the chloride.
Chloride of Potassium - - -	40	36	40
— Sodium - - - -	24	36	24
— Calcium - - - -	20	36	20
— Barium - - - -	70	36	70
— Strontium - - - -		36	44
— Magnesium - - - -	12	36	12
— Manganese - - - -	28	36	28
— Zinc - - - -	33	36	33
— Iron, 1st - - - -	28	36	28
— 2d - - - -		72	
— Tin, 1st - - - -	59	36	59

*Table of the Principal Compounds of Metals with Chlorine:
Continued.*

Name of chloride.	Equiv. of metal.	Proportion of chlorine.	Equiv. of metal deduced from chloride.
Chloride of Tin, 2d - - - -		72	
— Arsenic - - - -	38½	72	23.46
— Antimony - - - -	44	36	44.21
— Bismuth - - - -	71	36	71.05
— Copper, 1st - - - -	64	36	66.05
— 2d - - - -		72	
— Lead - - - -	104	36	103.52
— Mercury, 1st - - - -	200	36	204.17
— 2d - - - -		72	
— Silver - - - -	110	36	110.14
— Gold - - - -	?	36	104.23

The following is the classification of the metals, adopted by Dr. Henry in the ninth edition of his work, published the present year, (1823.) Being entirely different from that heretofore adopted in the work, it was considered to be sufficiently interesting to be inserted in this supplement to the eighth edition.—B.

Classification of Metals.—Vol. II. p. 51.

THE circumstance, on which a subordinate division of the metals is perhaps best founded, is the nature of their relation to oxygen. Without creating more of these subdivisions than are absolutely necessary, it appears to me that they may be conveniently arranged under the following heads:—

CLASS I. METALS, THAT AFFORD OXIDES, WHICH CANNOT BE REDUCED TO A METALLIC FORM WITHOUT THE ADDITION OF COMBUSTIBLE MATTER.

CLASS II. METALS, THE OXIDES OF WHICH ARE DECOMPOSED BY HEAT ONLY.

I. THE FIRST CLASS, which have been termed *base metals* to distinguish them from the *noble* or *perfect*, may be again subdivided as follows:—

1. *Metals that are either known from experiment, or believed from analogy, to absorb oxygen at high degrees of heat, and to decompose water at common temperatures.* The metals, that have been actually ascertained to produce these effects, are six, viz.

Potassium,
Sodium,
Lithium,
Calcium,
Barium, and
Strontium.

There is a striking resemblance, also, between the properties of the oxides of these metals. Those of potassium, sodium, and lithium, are readily soluble in water; have a peculiar acrid taste; change certain blue vegetable colours to green, and some yellow ones to brown; neutralize acids, forming salts, which, for the most part, are easily soluble; and, from these similarities, have been classed together under the name of **ALKALIES**. With these oxides, those of calcium, barium, and strontium agree so nearly, that they also might, without any impropriety, be called alkalies; but, being themselves, as well as several of their neutral compounds with acids, less readily soluble in water, they have been termed, perhaps without sufficient reason, **ALKALINE EARTHS**.

The metals, belonging to this sub-division, which are as yet distinctly known to us only when in combination, but which are presumed from analogy to have a similar relation to oxygen and water with those already enumerated, are the seven following:

Magnesium,
Glucinum,
Yttrium,
Aluminium,
Thorium,
Zirconium, and
Silicium.

The oxides of these seven metals are sparingly soluble in water; have little or no taste; do not afford solutions in water which are capable of acting on vegetable blue or brown colours; but (silica excepted) unite with acids, and form neutral salts. They have been hitherto termed **EARTHS**, or **EARTHS PROPER**; though the grounds of their distinction from other metallic oxides are constantly becoming more limited. It has been questioned whether one of these bodies, silica, does not, as to its powers of combination, exhibit rather the qualities of an acid; and whether its base, which some writers have called silicon, can properly be arranged among metals.

2. *The second sub-division includes those metals, which absorb oxygen from atmospheric air at high temperatures; and decompose water, but not under a red heat.* They are five in number, viz.

Manganese,
Zinc,
Iron,
Tin, and
Cadmium.

The last of these is associated with the others, from the agreement of its general properties with those of tin.

3. *Metals of the third sub-division are capable, like the foregoing, of absorbing oxygen at high temperatures, but not of decom-*

posing water at any temperature. There are no less than fourteen which answer to this description; viz.

Arsenic,
Molybdenum,
Chromium,
Tungsten,
Columbium,
Antimony,
Uranium,
Cerium,
Cobalt,
Titanium,
Bismuth,
Copper,
Tellurium, and
Lead.

Of these metals, the first five are distinctly acidifiable; and the nine others are oxidizable only.

II. THE SECOND CLASS OF METALS, the oxides of which are reducible by heat, without the addition* of combustible matter, are nine in number; viz.

Mercury,
Silver,
Gold,
Platinum,
Palladium,
Rhodium,
Iridium,
Osmium, and
Nickel.

The three first have been long classed together under the name of *noble or perfect metals*; and the remaining ones have been associated with them, as they have been successively discovered. Nickel, which was for some time placed among the imperfect metals, was removed a few years since into this class, after a more accurate investigation of its relation to oxygen.

ADDITIONS TO THE SECTION ON GOLD.

Solution of Gold in Aqua Regia:—Chlorides, Iodide, and Oxides of Gold.—Vol. II. p. 52.

IN rendering a solution of gold in aqua regia neutral, in order to avoid all risk of decomposition, instead of evaporating to dryness,

the liquid may be removed from the fire, when sufficiently concentrated to become solid on cooling. The solid obtained has a deep brownish-red colour, is very fusible, and readily dissolves in water, giving a reddish-yellow solution. The solution, Pelletier believes to be a real *chloride*, and not a *muriate*, though occasionally it contains a little free muriatic acid. If, instead of removing the mass from the fire, it be heated still longer, chlorine is disengaged, and a lemon-yellow compound is left, which is a *sub-chloride*. By strongly urging the heat, the whole chlorine is expelled, and metallic gold only remains.

Concentrated sulphuric acid, poured into the solution of chloride of gold, throws down an *anhydrous chloride*. If heat be applied, chlorine is disengaged, and a yellow sub-chloride falls; or, if the heat be continued, metallic gold is separated. Arsenic and phosphoric acids produce the same effects.

Chlorides of Gold.—According to Pelletier, there are two chlorides of gold,

	Metal.	Chloride.
The <i>protochloride</i> , or subchloride	= 100	+ 14.715
The <i>perchloride</i> (soluble)	= 100	+ 44.145

It is in the state of perchloride that gold exists when dissolved by *aqua regia*.

The *sub-chloride* of gold, on adding water to it, is converted into one-third metallic gold, and two-thirds chloride. Acids, containing no water, do not produce any change on the sub-chloride; but dilute acids convert it into metallic gold and chloride of gold, the latter remaining in solution. Hence, by acting with acids on gold treated with *aqua regia*, we cannot obtain salts with base of oxide of gold, for that product, being a true chloride, contains no oxygen. For the same reason, sulphate or phosphate of soda, added to the solution, do not form sulphate or phosphate of gold. When sulphate or nitrate of silver is added to the chloride of gold, the whole of the sulphuric or nitric acid remains in the liquor, and a brownish-yellow precipitate is formed, which is a mixture of chloride of silver and oxide of gold. The latter is taken up by muriatic acid. This precipitate, if dried and heated in a retort, yields oxygen gas by the decomposition of the oxide of gold.

When pure potassa, not in excess, is added to liquid chloride of gold at common temperatures, no immediate precipitation ensues. After some time, however, or immediately if heat be applied, a very light bulky reddish-yellow precipitate appears, containing only five-sixths of the gold present in the chloride. An excess of alkali re-dissolves much of this precipitate; which is a *hydrated oxide of gold* with a little chloride. But if, instead of adding more alkali, the precipitate be well washed with water, and dried, it shrinks greatly in bulk, and a black powder remains, which is not entirely soluble in muriatic acid.

If a considerable excess of potassa be mixed with the chloride of gold, the supernatant liquid acquires a light greenish yellow; and a blackish sediment is formed, in which not more than $\frac{1}{10}$ th of the gold is found that was held in solution. The remaining $\frac{9}{10}$ ths, united with oxygen, have combined with the potassa, which acts the part of a base, while the oxide of gold serves as a salifying principle. To this compound, Pelletier gives the name of *aurate of potassa*. Oxide of gold appears, therefore, adapted to unite with bases, rather than itself to form a base for combination with acids, with most of which it refuses to unite.

The precipitation of gold by a due quantity of potassa seems to be the effect of a double affinity, the chlorine passing to the potassium, and the oxygen of the potassa to the gold. Some chloride of gold remains undecomposed. When excess of potassa is used, the product is a mixture of chloride of potassium and aurate of potassa.

Baryta produces similar effects on chloride of gold, but seems to have a stronger affinity for the oxide.

When chlorides of potassium, sodium, or barium, are boiled with oxide of gold, the resulting liquid contains a mixture of aurate of alkali, and chloride of gold.

Iodide of Gold may be obtained by acting on oxide of gold with hydriodic acid, or by mixing chloride of gold with hydriodate of potassa, and washing and drying the precipitate. It is insoluble in cold water, and very sparingly soluble in hot. It is decomposed by heated nitric or sulphuric acids, which reduce the gold and set iodine at liberty. Liquid alkalies decompose it instantly, and it is decomposed by a temperature of 260° Fahr. It is constituted, according to Pelletier, of

Iodine	34	100
Gold	66	194.1176

100

Oxides of Gold.—The best process for obtaining *oxide of gold*, according to Pelletier, is to precipitate chloride of gold by magnesia. Muriate of magnesia is formed, which may be removed by washing, and the excess of magnesia may be dissolved by diluted nitric acid. In this case, the magnesia is doubtless first converted into a chloride, and parts with its oxygen to the gold. The oxide must be dried at a very low heat.

There is considerable disagreement as to the composition of the oxide of gold. Pelletier, from the composition of the iodide, deduces the quantity of oxygen combined with 100 parts of gold to be 10.03. This is assigned as the composition of the peroxide; but besides this, he supposes that there is a protoxide containing only one-third of the oxygen which exists in the peroxide. Their composition may, therefore, be stated, according to Pelletier, as follows:

	Metal.	Oxygen.
Protoxide	100 +	3.3495
Peroxide	100 +	10.03

Equivalent Number for Gold.—Vol. II. p. 55.

THERE is considerable difficulty in fixing upon a number to represent the weight of the atom of gold, on account of the uncertainty respecting the smallest proportions of oxygen, chlorine, &c. with which it is capable of forming a chemical compound. It appears to me that the only well-ascertained oxide of gold is that which contains, according to Oberkampf, 10.01, and to Berzelius, 12.07 oxygen, on 100 of the metal; and if this be the only oxide, the atom of gold will be represented either by 80, or by 70, as we take the experimental result of the former or the latter chemist. The constitution of the protoxide, as stated by Pelletier, would raise the representative number to 240; that of the iodide to 242; and of the proto-chloride to 244; but the existence of an oxide and a chloride with so small a relative proportion of oxygen and of chlorine, has not yet been sufficiently established. The composition of the oxide, assigned by Berzelius, is confirmed by Oberkampf's analysis of the sulphuret, viz. 100 metal and 24.39 sulphur; for this agrees with the relative atomic weights of oxygen and sulphur, the latter of which is shown, by a variety of well-ascertained facts, to be double that of the former. The whole subject appears, however, to require farther investigation, before an equivalent number can be obtained for gold, entitled to our full confidence.

ADDITIONS TO THE SECTION ON PLATINUM.

Sulphate of Platinum, and a New Substance formed from it by the Action of Alcohol.—Vol. II. p. 59.

FROM the sulphuret, the *sulphate of platinum* is best prepared by the action of nitric acid. It is soluble in water, in alcohol, and ether; and the first mentioned solution, Mr. Davy finds to be the best test yet tried for discovering gelatin.

The action of alcohol on sulphate of platinum occasions the formation of a substance, which is possessed of very singular properties. Equal volumes of a strong aqueous solution of this sulphate and of alcohol, heated together, deposite a black powder,

O (S)

which, after being welledulcorated, and dried at a very gentle heat, exhibits the following properties:

It is black and in small lumps, which are soft to the touch, and easily reduced to an impalpable powder. This powder is tasteless, and insoluble in water either hot or cold. When gently heated on a slip of platinum, a feeble explosion takes place, accompanied with a hissing noise, and a flash of red light, and the platinum is reduced. Brought into contact with ammoniacal gas, it becomes red-hot, and scintillates. It is instantly decomposed by alcohol, as is shown in a very striking manner by moistening paper, sand, cork, or sponge, with that fluid, and placing the smallest particle of the powder on them. It hisses, and becomes red-hot; and Mr. E. Davy, to whom we owe its discovery, proposes it as an excellent means of kindling a match. It appears to consist of $96\frac{1}{2}$ per cent. platinum, with nitrous acid, a little oxygen, and a very minute proportion of carbon. The nitrous acid is accounted for, by the peculiar way in which the sulphate had been formed.

Alloys of Platinum.—Vol. II. p. 60.

PLATINUM is capable of entering into combination with other metals, and of forming alloys, which are not, in general, characterized by useful properties. Its affinity for lead is strikingly shown by the following experiment. If a piece of lead foil, and another of platinum foil, of equal dimensions, be rolled up together, and the flame of a candle be cautiously directed by a blow-pipe towards the edges of the roll, at about a red heat, the two metals will combine with a sort of explosive force, scattering their melted particles, and emitting light and heat in a surprising manner. (*Ann. of Phil.* xiv. 230.) A small bit of tin, zinc, or antimony, rolled in platina leaf, and treated in like manner, exhibits similar appearances.

With potassium and sodium, platinum affords brittle compounds. In the proportion of 1-16th, it renders gold pale; it amalgamates with mercury, and diminishes the fusibility of the fusible metals.

ADDITIONS TO THE SECTION ON SILVER.

Action of a Current of Air or Oxygen on Silver in a State of Fusion.—Vol. II. p. 61.

FROM some curious facts, which are stated by Mr. Lucas in vol. iii. N. S. of the Manchester Society's Memoirs, it appears that

silver, when melted, and exposed to a current of air or of oxygen gas, forms a temporary union with oxygen, which is again given off in the state of gas, when the metal cools spontaneously, or is poured into cold water. This property, it has been shown by Chevallot, (*Ann. de Chim. et Phys.* xiii. 299), belongs only to pure silver, and not to silver alloyed even with a very small proportion of copper.

Composition and Properties of Chloride of Silver.—Vol. II.
p. 62.

To know the composition of chloride of silver, 100 grains of the metal may be dissolved in nitric acid, and precipitated by a solution of common salt. The precipitate being carefully washed, dried, and fused, the increase of weight on the silver shows the quantity of chlorine which has been gained. Different chemists have given different statements. Wenzel found that 100 of silver gave 131.4 of chloride; Davy, 132.5; Bucholz, Rose, Marcet, and Gay-Lussac, 133.3; and Berzelius, from several experiments, considers 132.75 as the true product. Taking Sir H. Davy's result, the composition of chloride of silver is

Silver	75.5	100.	307.69
Chlorine	24.5	32.5	100.

100.

And the equivalent number for silver, deducible from this analysis, is 110.7, from Berzelius's 109.9. It will perhaps be very near the truth if taken at 110, a number agreeing with that indicated by the composition of the oxide.

Chloride of silver is insoluble in water, but is very soluble in liquid ammonia. The solution sometimes, when heated, affords fulminating silver, and should therefore be treated with caution. It furnishes crystals, which, by exposure to the air, are decomposed, the ammonia escaping, and chloride of silver remaining. Chloride of silver also dissolves in hypo-sulphurous acid. It is decomposed by a stream of hydrogen gas, and, when moistened with water, by any materials capable of affording hydrogen, such as zinc filings and dilute sulphuric acid. Zinc and tin decompose it also in the dry way.

If a little fused chloride of silver and a little zinc be heated together in a glass tube, a violent action takes place, chloride of zinc is formed, and silver set at liberty, and the heat generally rises high enough to fuse the silver. Zinc alone, brought into contact with moist chloride of silver, decomposes it; but hydrogen, freed from all impurities and directed upon moistened chloride of

silver in the dark, effects no change whatever. (Faraday, Journ. of Science, viii. 375.)

Process of Cupellation.—Vol. II. p. 65.

THE object of *cupellation* is to oxidize the baser metals that may be mixed with silver; and to remove the oxide when formed, leaving the silver pure. To assist this, a proportion of some metal is added, which is not only readily oxidizable, but which affords a fusible oxide. Lead is generally employed for this purpose. A small shallow crucible, called a *cupel*, (which is best made of the internal slough of a bullock's horn calcined to whiteness), is heated to redness under a muffle. Upon this a small button of pure lead is first placed; and then the silver, laminated, accurately weighed, and wrapt in lead foil. The metals melt together, and an appearance called *fulguration*, or *scintillation*, ensues. The lead is gradually oxidized, and the oxide carries down the baser metals into the cupel, a button of pure silver being finally left. The process requires a nice regulation of the heat, and its success depends greatly on the skill and experience of the operator. In cooling the button, care also is necessary, as the accuracy of the result is apt to be destroyed by the spirting of the fluid metal from beneath the congealed crust.

ADDITIONS TO THE SECTION ON MERCURY.

Manufacture and Properties of Corrosive Sublimate and Calomel.—Vol. II. p. 68.

THE principal use of sulphate of mercury is in the formation of corrosive sublimate and calomel. The following methods of preparing these compounds, have been described by Mr. Brande: For corrosive sublimate, 50 pounds of mercury are boiled to dryness in a cast iron pan with 70 pounds of sulphuric acid; 73 pounds of super-sulphate of mercury are thus formed, which being perfectly mixed with 120lbs. of muriate of soda and sublimed, yield from 63 to 65lbs. of corrosive sublimate.

To form calomel, 50lbs. of mercury are boiled with 70lbs. of sulphuric acid to dryness; 62lbs. of the dry salt are triturated with 40½lbs. of mercury, until the globules disappear, and 34lbs. of common salt are then added. The mixture is submitted to heat

in earthen vessels, and from 95 to 100lbs. of calomel are the result. This is first to be ground to a fine and impalpable powder, and then washed with large quantities of distilled water. (Manual, vol. ii.)

Bi-chloride of Mercury (Corrosive Sublimate) is a white semi-transparent mass, imperfectly crystallized. Its specific gravity is 5.2. Light has no action on it in its solid form. It has an acrid and nauseous taste, and leaves in the mouth a permanent metallic flavour. It is a violent poison. Water at 60° Fahr. dissolves rather more than one-twentieth of its weight. The solution is decomposed by light, and calomel is formed. Alcohol, sp. gr. .816, takes up half its weight, and acquires the specific gravity 1.08. Ether, sp. gr. .745, dissolves one-third of its weight, and the solution has the same specific gravity as that effected by alcohol. Muriatic acid, sp. gr. 1.158, at 70° Fahr. takes up twice its weight of corrosive sublimate, and the solution is of specific gravity 2.412; but, on lowering its temperature a few degrees, it suddenly becomes solid. From Dr. Davy's experiments, (Phil. Trans. 1822), corrosive sublimate appears not to be soluble in the sulphuric or nitric acid. It is capable of uniting, and forming a double salt, with muriates of ammonia, potassa, soda, baryta, and magnesia, all of which greatly increase its solubility; and the solutions by these menstrua, as well as by alcohol and ether, Dr. Davy finds, undergo no change by exposure to the light. From the watery solution, alkalis throw down peroxide of mercury, first as an orange, and afterwards as a brick-red precipitate.

Proto-chloride of Mercury (Calomel) is white, crystalline, and very heavy, its specific gravity being 7.2. It is tasteless and nearly insoluble, and may be taken in doses of several grains, without any effect but that of a purgative. When a mass of it is scratched, it gives a yellow streak, which is not the case with the perchloride; and when very finely powdered, it has a light buff colour.

When a very small quantity of calomel (about 10 gr.) is well triturated with a little water, and then with a considerable quantity of liquid potassa, poured on it at once, an intensely black precipitate is obtained, which, when dried at a gentle heat, and rubbed in a mortar, affords about one-fourth its weight of revived mercury. The remainder is the protoxide.

ADDITION TO THE SECTION ON COPPER.

Acetates of Copper.—Vol. II. p. 82.

By the solution of verdigris in distilled vinegar and evaporation, a salt is obtained in regular crystals. These crystals have been analyzed by Mr. Richard Phillips, and shown to consist of

2 atoms of acetic acid . .	$50 \times 2 =$	100
1 atom of peroxide of copper . . .	$=$	80
3 atoms of water	$9 \times 3 =$	27

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or, of

Acid	50.11	100.
Base	37.77	75.37
Water	12.12	

 100.

A previous analysis by Dr. Ure had already given the same results, except in assigning two atoms only of water, and a different equivalent for acetic acid. Both concur in showing that the salt is strictly a *binacetate*, and by that name it is proper to designate it. (Ann. of Phil. N. S. i. 418, ii. 21.)

Binacetate of Copper forms large and beautiful crystals. It is soluble in 20 parts of water at 60°, or in five parts at 212°. When distilled *per se*, it yields concentrated acetic acid, which may be purified by a second distillation; and in the retort a compound is left of charcoal and oxide of copper, which sometimes kindles spontaneously like pyrophorus. When this substance is calcined with free access of air, it becomes *peroxide*.

Verdigris, from the recent experiments of Mr. Phillips, appears to consist essentially of very minute blue crystals, which are composed of

Acetic acid	28.50	1 atom	50
Peroxide	43.25	1 atom	80
Water	28.45	6 atoms	54

 100.

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In verdigris, when dried for sale, the same relative proportion of acid and base exist, but the water is reduced to 25 parts, or a little more, in 100; and there is a quantity of insoluble impurity varying from 0.5 to 2 per cent.

The blue crystals, found in verdigris, are, therefore, a true *acetate of copper*, consisting of an atom of acid + 1 atom of peroxide. When acted upon by water, they are decomposed; a green insoluble powder is obtained, which is a real *subacetate*, constituted of 1 atom of acid + 2 of peroxide. The blue solution contains a *binacetate*. Three distinct compounds, therefore, exist of acetic acid and peroxide of copper, the *subacetate*, *acetate*, and *binacetate*.

The subacetate, constituted of	1 atom acid + 2 base,
acetate	1 atom acid + 1 base,
binacetate	2 atoms acid + 1 base.

ADDITION TO THE SECTION ON IRON.

Tempering of Steel:—Its newly discovered Alloys with Several Metals.—Vol. II. p. 94.

STEEL, when ignited and suddenly cooled, is rendered so hard and brittle as to be unfit for any useful purpose. To remove this defect, it requires what is called *tempering*, which consists in heating it up to a point that varies with the object to which the steel is destined. When thus heated, it assumes various colours, which were formerly the only guide for judging of the degree of temper; but this is now much better ascertained by using a bath of mercury or fusible metal, and regulating its temperature by the thermometer, which may range from 400° to 600° Fahr. according to the use for which the steel is intended.

Steel admits of being alloyed with several other metals, and the alloys, as appears from a recent investigation of Messrs. Stodart and Faraday, (Phil. Trans. 1822), are applicable to various important uses. The silver alloy, containing about $\frac{1}{100}$ of that metal, may be advantageously applied to every purpose for which good steel is required. With $\frac{1}{100}$ of platinum, steel acquired such an increase of toughness as well as of hardness, as fully to compensate its additional cost. With rhodium, as well as with iridium and osmium, very valuable compounds were obtained; but till these metals can be had at less cost and in greater quantity, their compounds with steel can be of little practical use, except for small and delicate instruments. In the analysis of these alloys, Mr. Faraday remarked that some of them, especially that into which platina entered in the proportion of not more than $\frac{1}{100}$, was acted on with great energy by dilute sulphuric acid, gas being evolved very rapidly, and the alloy dissolved in a time during which pure steel was scarcely affected. This effect, he ascribes to the formation of a Voltaic combination by the two metals. It could not be owing to the mere separation of the particles of steel by the interposed foreign metal; for the effect was diminished by increasing the proportion of platina.

ADDITIONS TO THE SECTION ON NICKEL.

Dr. Thomson's Process for obtaining pure Nickel.—Vol. II. p. 95.

To obtain pure nickel, Dr. Thomson has employed with success the following process, the outline of which was suggested to him by Dr. Wollaston. Reduce to coarse powder a quantity of the brittle reddish alloy, known in commerce by the name of *speiss*, which is chiefly a compound of arsenic and nickel; pour upon it a quantity of dilute sulphuric acid; place the mixture in a Wedgwood's evaporating dish, and add, at intervals, the quantity of nitric acid requisite to enable the acid to act upon the speiss. By this operation, a deep grass-green liquid is obtained, while a considerable quantity of arsenious acid remains undissolved. Decant the green

liquid, and evaporate it till it is sufficiently concentrated to yield crystals, when it is to be set aside in a cool place. A deposit of beautiful crystals of sulphate of nickel will be obtained. By concentrating the liquid still farther, more crystals of sulphate of nickel will fall; but after a certain time the liquid, though its colour continues dark green, refuses to yield any more crystals of the sulphate. When evaporated still farther and set aside, a very abundant deposit is made of an apple-green salt, which adheres very firmly to the evaporating dish, and which is a double salt consisting of sulphate of nickel and arseniate of nickel. Dissolve this in water, and pass a current of sulphuretted hydrogen gas through it, as long as any precipitate appears. Filter and evaporate again, when it will still be converted into an apple-green matter. When this is dissolved in water, the liquid becomes opaque, owing to the separation of a quantity of arsenious acid. The liquid, being filtered and again evaporated, yields crystals of true sulphate of nickel. For greater security, the whole of the sulphate of nickel, which has been obtained, may be re-dissolved and crystallized a second time.

The pure sulphate is next to be dissolved in water, and decomposed by carbonate of soda. The carbonate of nickel, when well washed and dried, is a light green-coloured powder. To reduce the metal, this carbonate is to be made up into balls with a little oil, which is to be put into a Hessian crucible, and surrounded with powdered charcoal. A cover is to be luted on the crucible, and it is to be exposed, for two hours, to the strongest heat that can be raised in a melting furnace. By this process, Dr. Thomson has always obtained a button of pure nickel in the metallic state. (*Ann. of Phil.* xiv. 144.)

Dr. Clarke, of Cambridge, has also shown that the crystals of nitrate of nickel, when placed in a cavity scooped out of a piece of charcoal, and exposed to the oxy-hydrogen blowpipe, afford a bead of metallic nickel. This, however, is a process obviously adapted to yield only very minute quantities of nickel. (*Ann. of Phil.* xiv. p. 142.)

Equivalent Number for Nickel.—Vol. II. p. 98.

M. LASSAIGNE has lately been induced by the consideration of the difficulty of purifying nickel from cobalt, to examine some of the compounds formed with nickel of known purity.

There are two oxides of nickel; the protoxide, which is formed whenever nickel is dissolved in acids, and the deutoxide, produced by the action of chlorine on the protoxide in the way pointed out by Thenard. The protoxide is of an ash-gray colour; it dissolves in acids, and forms green solutions, from which alkalies throw down an apple-green hydrate or hydroxide. This oxide, obtained by dissolving nickel in nitric acid, and gently calcining the product, consists of

Nickel	86.84	100	1 atom = 40
Oxygen	16.66	20	1 ditto = 8
	<hr/>	<hr/>	<hr/>
	100.	120	48

The deutoxide of nickel is a brilliant black, and has many analogies with peroxide of manganese, like which it gives off oxygen at a red heat, and evolves chlorine from muriatic acid. It is constituted of

Nickel	71.43	100	1 atom = 40
Oxygen	28.57	40	2 ditto = 16
	<hr/>	<hr/>	<hr/>
	100.	140	56

The protochloride, obtained by evaporating to dryness a solution of nickel in muriatic acid, consists of

Nickel	52.64	100	1 atom 40
Chlorine	47.36	90	1 ditto 36
	<hr/>	<hr/>	<hr/>
	100.	190	76

The deutochloride, which sublimes, when the foregoing compound is heated, in light shining yellow crystals, is formed of

Nickel	35.72	100	1 atom 40
Chlorine	64.28	180	2 ditto 72
	<hr/>	<hr/>	<hr/>
	100.	280	112

The sulphuret consists of

Nickel	71.43	100	1 atom 40
Sulphur	28.57	40	1 ditto 16
	<hr/>	<hr/>	<hr/>
	100.	140	56

All these numbers concur in fixing the equivalent of nickel at 40; but before finally adopting that number, it will be desirable that the experiments should be confirmed by careful repetition.

ADDITIONAL SECTION.

ON THE NEWLY DISCOVERED METAL CADMIUM.

CADMIUM was discovered, in the autumn of 1817, by Stromeyer, in an oxide of zinc, which had been prepared for medicinal use from an ore of zinc brought from Silesia. He ascertained its principal properties and combinations; and has since extracted it from various other ores of zinc. Dr. Clarke has shown, that it exists in

the ores of zinc from Derbyshire and Mendip, and in the zinc of commerce; and Mr. Herapath, of Bristol, has pointed out an abundant source of it in the sublimate, which, in the process for obtaining zinc by distillation, rises before the zinc, in what the workmen call the *brown blaze*. Of this sublimate, which is attached to the roof of the vault, it forms from 12 to 20 per cent.

The presence of cadmium, in an ore of zinc suspected to contain it, may be discriminated by directing the blue flame of a candle upon a small fragment placed on a slip of platinum foil. If any cadmium be present, its oxide will be reduced, volatilized, and carried along the slip of platinum, coating it with its peculiar reddish-brown oxide. Dr. Wollaston, to detect cadmium, dissolves the ore of zinc in muriatic acid, gets rid by heat of the excess of acid, and adds distilled water. All the metals that iron will precipitate he removes by a rod of iron, and filters the liquor into a platinum capsule containing a piece of zinc. The cadmium, if any be present, will coat over the surface of the capsule with a precipitate of a dull leaden hue, and will adhere so firmly that it may be washed, and thus freed from any remaining solution of zinc. Muriatic acid will dissolve the lead coloured precipitate with effervescence, and either carbonated or caustic potassa will yield a white precipitate; which may be tested before the blow-pipe in the manner already described.

To separate cadmium from the ores of zinc, Stromeyer dissolves the ore in sulphuric acid; and through the solution, which ought to contain an excess of acid, sends a current of sulphuretted hydrogen gas. The precipitate is well washed, dissolved in concentrated muriatic acid, and the excess of acid expelled by evaporation. The residue is dissolved in water, and precipitated by carbonate of ammonia, an excess of which must be added, to re-dissolve any zinc or copper that may have been thrown down by the sulphuretted hydrogen gas. Carbonate of cadmium alone remains, which, after being heated to drive off the carbonic acid, is reduced by mixing it with lamp-black, and exposing it to a moderate red heat in a glass or earthen retort.

Cadmium resembles tin very nearly in colour, lustre, and in the sound it emits when bent. It is somewhat harder than tin, and surpasses it in tenacity. It is very ductile, and may be reduced to fine wire, or thin plate; yet, when long beaten, it scales off in different places. Its specific gravity is 8.604 before hammering, and 8.694 afterwards; or, according to Mr. Children, 8.67 before and 9.05 after being hammered. It melts at a heat below redness, and is volatilized by a heat not much greater than that required to vaporize mercury. Its vapour has no odour. It condenses in drops as readily as mercury, and these, on congealing, present distinct traces of crystallization.

Cadmium is as little altered by exposure to the air as tin. When heated in the open air, it burns as readily as the latter metal, and is converted into a brownish-yellow oxide. This oxide, which is its only one, consists of 100 metal + 14.352 oxygen, which gives 56 for the equivalent number of the metal, and 64 for that of the

oxide. This oxide is soluble in ammonia, but not in carbonate of ammonia, or in potassa or its carbonate, which even precipitate it from its solution in ammonia. By availing himself of this property, Mr. Children separated it from oxide of zinc, which is not thrown down by the fixed alkali, and thus verified its presence in compounds containing much zinc and little cadmium.

With the acids, oxide of cadmium unites and forms salts, which agree in the following characters. Fixed alkalies throw down a white hydrated oxide, as does ammonia, with this difference, that the latter, added in excess, re-dissolves the precipitate. Prussiate of potassa causes a white sediment, as does oxalate of ammonia. Sulphuretted hydrogen, and the hydro-sulphurets, throw down cadmium of a yellow or orange colour, like orpiment. No change is produced by chromate of potassa, succinate or benzoate of ammonia, infusion of galls, or sulphate of soda.

Chloride of Cadmium crystallizes in small rectangular prisms, perfectly transparent, which effloresce when heated, and are very soluble. At a high temperature, it sublimes in small micaceous plates: 100 parts of the fused chloride consist of 38.61 chlorine + 61.39 metal. This gives 57 for the equivalent of cadmium, differing very little from the number deduced from the oxide.

Iodide of Cadmium forms large and beautiful hexahedral tables, of a metallic or pearly lustre. At a high temperature, the iodine escapes. It consists of 100 metal + 227.43 iodine.

Nitrate of Cadmium crystallizes in prisms or needles, which are deliquescent. Its constituents are 100 acid + 117.58 oxide.

The *sulphate* crystallizes in large rectangular prisms resembling sulphate of zinc; which are very soluble in water. They effloresce in the air, and at a gentle heat lose their water of crystallization, amounting to 34.26 on 100 of the dry salt. The neutral sulphate consists of 100 acid + 161.12 oxide.

The *carbonate* is pulverulent and insoluble in water, and readily decomposable by heat. It consists of 100 acid + 292.88 oxide.

The *phosphate* is pulverulent and insoluble. It is constituted of 100 acid + 225.49 oxide.

Cadmium unites with sulphur, as with oxygen, in only one proportion, which is that of 100 metal to 28.172 sulphur. The sulphuret has a yellow colour with a shade of orange. Concentrated muriatic acid acts readily upon it, and evolves sulphuretted hydrogen gas. The sulphuret may be formed by heating sulphur either with the metal or the oxide, or by precipitating a solution of cadmium by sulphuretted hydrogen.

Phosphuret of cadmium has a gray colour and a feeble metallic lustre.

Cadmium unites with other metals. Its alloy with copper is white, with a slight tinge of yellow. It unites also with cobalt, platinum, and mercury, and probably with other metals.

From a survey of its salts, it appears that their analysis does not lead to a perfect agreement as to the equivalent of its oxide, and consequently of that of the metal. None of the results, however,

is very remote from affording 64 for the number representing the oxide, from which deducting 8, we obtain 56 for the equivalent of cadmium.

ADDITIONS TO THE SECTION ON ANTIMONY.

Preparation and Composition of the Oxides of Antimony.— Vol. II. p. 114.

BERZELIUS has described four compounds of oxygen with antimony; but the first, obtained by the long exposure of the metal to a humid atmosphere, or by making that metal the positive conductor in a galvanic arrangement, which he has called *suboxide*, cannot be considered as a definite compound. The next, which is the true *protoxide*, may be obtained from muriate of antimony, in the manner described in the body of the work; or by boiling 50 parts of powdered metallic antimony with 200 of concentrated sulphuric acid to dryness; washing the remainder, first with a weak solution of potassa, and then with hot water, and drying; or by precipitating the compound called *emetic tartar* with pure ammonia, and edulcorating the precipitate with plenty of hot water. It appears to be the only oxide which is capable of acting as a true base with acids, and is that which gives activity to the principal medicinal preparations of antimony.

The *second* or *white oxide* may be formed by the method given in the body of the work.—Vol. II. p. 115.

The *third* or *yellow oxide* was obtained by Dr. Thomson, by dissolving antimony in nitric acid, evaporating to dryness, and exposing the product for some hours to a heat of 500° Fahr. A yellow powder remained, of which $7\frac{1}{2}$ parts, exposed to heat, left 7 of white deutoxide; and 100 grains by distillation gave very nearly 19 cubic inches of oxygen gas. (Ann. of Phil. N. S. ii. 125.)

The composition of these oxides is thus stated by Berzelius.

	Metal.	Oxygen.	Metal.	Oxygen.
1. Protoxide	84.32	15.68	100	18.6
2. Deutoxide	80.13	19.87	100	24.8
3. Peroxide	72.85	27.15	100	37.20
Ditto (corrected 1821*) . . .	76.34	23.66	100	31.

Dr. Thomson was led, by his experiments, to assign to these oxides the following proportions:

Protoxide	100 metal	+ 18.2 oxygen
Deutoxide	100 do.	+ 27.3 do.
Peroxide	100 do.	+ 36.4 do.

These proportions, it is evident, are more consistent with the general law of chemical combination, than the later results of Berzelius; though they present, with respect to the deutoxide, the same anomaly as in the case of one or two other metals, viz. that the multiple of the oxygen of the first oxide is $1\frac{1}{2}$, and not an entire number. If Berzelius's analysis of the protoxide be correct, the equivalent number for antimony must be 43; but Dr. Thomson's determination would make it 44. Till its composition is decided, we may assume for

The equivalent number of antimony . . . 44	
<hr/>	of the protoxide $44 + 8 = 52$
<hr/>	of the deutoxide $44 + 12 = 56$
<hr/>	of the peroxide $44 + 16 = 60$

The peroxide is precipitated from its combinations in the form of a white hydrate, 100 grains of which, when exposed to a red heat, give 5 grains of water, and 90.48 grains of deutoxide, the loss (4.52) consisting of oxygen. (Berzelius.)

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Preparation of Antimonial Powder, and Emetic Tartar.—
Vol. II. p. 117.

THE medicinal preparation, called James's powder, was found by Dr. Pearson to consist of 57 protoxide of antimony, and 43 phosphate of lime; and it has been imitated in the *pulvis antimonialis* of the London Pharmacopœia, which is formed by calcining the native sulphuret with hartshorn shavings. The preparation appears to be often uncertain, and even almost inert, and to vary as to the state of oxidation in the antimony, containing sometimes a large proportion of the peroxide.

Tartarized Antimony, or Emetic Tartar, is a triple salt of protoxide of antimony, potassa, and tartaric acid. It is best prepared according to Mr. R. Phillips (on the London Pharmacopœia, p. 80.) by boiling 100 parts of metallic antimony to dryness with 200 of sulphuric acid. One hundred parts of the resulting subsulphate, boiled in an iron vessel with an equal weight of bi-tartrate of potassa, give at the first crystallization 90 parts of tartarized antimony; and a further quantity may be obtained by evaporating the solution. The primitive crystal of this salt is a rectangular octohedron, the planes of which meet at the summit at an angle of about 63° . Like other substances possessing a similar primitive form, it admits of the tetrahedron as one of its varieties. This salt ought to form, with a dilute solution of sulphuret of potassa, an orange-coloured precipitate.

ADDITIONS TO THE SECTION ON SELENIUM.

Additional Properties of Selenium.—Vol. II. p. 119.

THE colour of Selenium varies a good deal. When rapidly cooled, its surface has a dark brown hue, and its fracture the colour of lead. Its powder has a deep red colour, but it sticks together when pounded, and then assumes a gray colour and a smooth surface. Its vapour has a deep yellow colour, more intense than that of chlorine, but not so deep as that of sulphur.

While selenium possesses some of the characters of metals, (the metallic lustre for example), it is destitute of others that are essential to its arrangement in that class. It has more transparency than any metal, and is distinguished, also from the metals, by the want of power to conduct electricity or heat. In some respects, it resembles tellurium but, on the whole, its properties are most analogous to those of sulphur; and it may be regarded as forming the connecting link between metals and non-metallic combustibles.

Compounds of Selenium and Oxygen.—Vol. II. p. 119.

Oxide of Selenium is formed by heating selenium in a close phial with common air, which acquires a very strong smell of horse-radish. Water agitated with this air imbibes the odour of the gas, and reddens litmus feebly, but this appears to be owing to the production of a small quantity of selenic acid. Selenic oxide gas is very sparingly soluble in water, and does not impart any taste to it. It does not combine with liquid alkalies. Its precise composition is unknown; but it appears to belong to the same class of oxides as carbonic oxide.

Selenic Acid.—Selenium dissolves in nitric and nitro-muriatic acids, and when the solution is evaporated in a retort, so as to expel the excess of those acids, there remains a white saline mass, which sublims on raising the temperature, and forms a vapour, the colour of which closely resembles that of chlorine. In the cold part of the apparatus, selenic acid condenses in very long four-sided needles. These crystals, when first taken out of the retort, have a dry aspect and a peculiar lustre. Exposed to the air, they adhere to each other, and the lustre becomes dull, but they do not liquefy.

Selenic acid has a sour taste, and leaves a slightly burning sensation on the tongue. It is very soluble in cold water, and dissolves in almost every proportion in boiling water. A saturated solution crystallizes, when rapidly cooled, in small grains, and when slowly cooled in striated prisms. The crystals dissolve in great abundance in alcohol, and the solution, when distilled, yields a fluid having an ethereal smell.

Selenic acid unites with different bases, and forms a class of salts called *Selenates* or *Seleniates*.

Selenic acid is easily reduced both in the moist and the dry way. When a plate of zinc or polished iron is introduced into a solution of selenic acid, mixed with muriatic acid, selenium is precipitated in the form of red, or brown, or blackish flakes. It is revived, also, by sulphuretted hydrogen and sulphurous acid gases.

From his investigation of selenic acid, Berzelius has inferred it to consist of

Selenium	71.261	100.00
Oxygen	28.739	40.33

100.

On the supposition that it is constituted of an atom of base + 2 atoms of oxygen, the equivalent number for selenium will be 41, and for selenic acid 57.

Compound of Selenium and Chlorine.—Vol. II. p. 120.

SELENIUM absorbs chlorine gas, and becomes hot and forms a brown liquid, which, by an additional quantity of chlorine, is converted into a white solid mass. This is stated by Berzelius to be a compound of muriatic and selenic acids, but it is probably composed of chloride of selenium and the latter acid. It has not yet been accurately separated into its component parts, for when heat is applied, both substances are sublimed.

Compound of Hydrogen with Selenium, or Selenuretted Hydrogen Gas.—Vol. II. p. 120.

BERZELIUS, by fusing together potassium and selenium, and adding water to the fused mass, obtained a hydro-selenuret of potash of a deep ale colour. By pouring diluted muriatic acid on the concentrated solution of this compound, a gas is disengaged, which has the following properties.

It has a smell resembling that of sulphuretted hydrogen. It is absorbed to a considerable amount by water, which acquires no colour, but after some minutes becomes slightly opalescent, and deposits a little selenium. The solution has an hepatic taste, reddens litmus paper, and gives a permanent brown stain to the skin. Exposed to the air, it is gradually but completely decomposed. It precipitates all metallic solutions when neutral, even those of zinc and iron, generally of a brown or black colour.

This gas produces violent effects on the organs of respiration, and a sharp and painful sensation in the nose, which is followed by the loss, for a time, of the sense of smelling. A small bubble not larger than a pea, when let up into the nostrils, beside the immediate effects which have been described, produced a mucous discharge, which continued 15 days.

To determine its composition, it was transmitted through a solution of acetate of silver; when a selenuret of silver was formed, from the known composition of which, Berzelius deduces the composition of this gas to be

Selenium	97.4 . . .	1 atom . . .	41
Hydrogen	2.6 . . .	1 do.	1
	<hr/>		<hr/>
	100.		42

This determination of the equivalent of selenium does not essentially differ from that deducible from the composition of selenic acid.

Selenium agrees then with sulphur and with tellurium, in affording a weak acid when united with hydrogen; an acid which, in all three cases, forms salts with those oxides only, whose radicals have a stronger affinity for oxygen than hydrogen has; while it reduces all other oxides, and forms compounds of their respective metals with selenium.

Phosphuret and Sulphuret of Selenium.—Vol. II. p. 120.

Phosphuret of Selenium.—Selenium is speedily dissolved by melted phosphorus, and, if added to saturation, a very fusible compound results, which, when cold, has a dark brown colour, much lustre, and a vitreous fracture. When this compound is digested in water, selenuretted hydrogen is formed, which, dissolving in the water, communicates to it a peculiar hepatic odour. The proportions of its constituents are unknown.

Sulphuret of Selenium.—One part of selenium, melted with 100 parts of sulphur, imparts to the sulphur a dirty yellow colour; but the only method of obtaining a sulphuret of selenium of determinate composition is to precipitate a solution of selenic acid by sulphuretted hydrogen gas, and to wash the precipitate with a little muriatic acid. A deep orange-coloured compound is formed, in which 100 parts by weight of selenium are united with 60.75 sulphur. It is attacked with difficulty by nitric acid, but more readily by nitromuriatic. It is soluble in the fixed caustic alkalies, as well as in alkaline hydrosulphurets, and gives a solution of a deep orange colour. When heated in the air, it burns at first with the odour of sulphurous acid, then with that of horse-radish.

ADDITIONS TO THE SECTION ON ARSENIC.

Sulphurets of Arsenic.—Vol. II. p. 122.

The sulphurets of arsenic have been examined by Klaproth, Laugier, and Berzelius. There are two sulphurets of this metal,

both of which are found native; a red compound, called *Realgar*, and a bright yellow one, named *Orpiment*. They may also be formed artificially, the red by heating white arsenic with sulphur; the yellow by dissolving white arsenic in muriatic acid, and precipitating by hydro-sulphuret of ammonia. Laugier and Klaproth found

In realgar . . .	100 arsenic united to	43.67 sulphur.
In orpiment . . .	100 ditto	63.93 ditto.

It appears, therefore, that orpiment and realgar are both sulphurets of arsenic, containing sulphur in the proportions of 1 to $1\frac{1}{2}$, or of 2 to 3. In orpiment, it may be observed, the sulphur is nearly double the oxygen in the arsenious acid. To agree with atomic proportions, it ought to be exactly so.

Orpiment is employed in calico-printing to deoxygenate indigo, which thus becomes capable of attaching itself to the cloth. M. Braconnot recommends realgar for dyeing wool, silk, or cotton, of a fine yellow colour. Having mixed 1 part of sulphur, 2 parts of white arsenic, and 5 of potash of commerce, melt them in a crucible at a heat near that of redness. The yellow mass thus obtained is to be dissolved in hot water, and filtered. It is then to be diluted, and sulphuric acid poured into it, of such strength as to produce a fleecy precipitate of a superb yellow colour. This dissolves with facility in ammonia, and gives a yellowish liquor, into which is to be poured an excess of ammonia for the purpose of discolouring it entirely. Goods plunged into this solution come out colourless, but they assume a fine yellow as the ammonia evaporates. The colour is durable, and resists acids but not alkalies. [Ann. de Chim. et Phys. xii. 98.)

Composition of Arsenious and Arsenic Acids.—Vol. II. p. 123.

From his earlier experiments on arsenic, Dr. Thomson had deduced the weight of the atom of that metal to be 4.750, oxygen being 1, corresponding with 38, when hydrogen is taken as unity; and had concluded, that, in arsenious acid, each atom of arsenic is united with $1\frac{1}{2}$ of oxygen, in arsenic acid with $2\frac{1}{2}$ atoms of oxygen. This, however, presents the anomaly of an atom of one body, combining with one or two atoms, and the fraction of an atom, of another body. To remove this difficulty, he has since proposed to double the weight of the atom of arsenic, and to consider arsenious acid as constituted of 1 atom of base + 3 of oxygen, and arsenic acid of 1 of base + 5 of oxygen, which gives their composition as follows:

Arsenious acid = 1 atom of arsenic	76
3 atoms of oxygen	24

Weight of its atom	100
8	

(Q)

Arsenic acid = 1 atom of arsenic	76
5 atoms of oxygen	40
	<hr/>
Weight of its atom	116

Berzelius, also, has been led, by his investigation of these acids, to conclude that the ratio of the oxygen in arsenic acid is to that in arsenious acid as 5 to 3, a deviation from the general law of acid compounds, limited to those with base of arsenic and phosphorus. Between these acids, indeed, there seems to be, in several respects, a considerable analogy, especially in their salts; which, though carefully neutralized when in solution, yet, when concentrated by evaporation, crystallize with an excess of alkali. Arsenic and phosphorus agree, also, in giving, with hydrogen, compounds that are not acid, and, in many other respects, present striking resemblances.

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Description of Several Arseniates.—Vol. II. p. 123.

Arseniate of Potassa was formed by Macquer, by distilling, in a retort, equal weights of nitre and arsenious acid. It crystallizes in four-sided rectangular prisms, terminated by very short four-sided pyramids. It is permanent in the air, and has a saline and cooling taste. It is soluble in about five times its weight of cold water, but is insoluble in alcohol. Dr. Thomson's analysis makes it to consist of

Arsenic acid	65.426
Potassa	27.074
Water	7.500

100.

Arseniate of Soda forms large rhomboidal prisms, which effloresce by exposure to a dry atmosphere. It has a cooling taste, resembling that of carbonate of soda, but less strong. It requires more than ten times its weight of cold water for solution, and the liquid has alkaline properties. It undergoes the watery fusion. Its solution, when dropped into most earthy and metallic salts, occasions precipitates, the peculiar appearances of which are exhibited by Dr. Thomson in a table published in the *Annals of Philosophy*, xv. 83.

Arseniate of Baryta was prepared by Berzelius, by mixing nitrate of baryta with neutral arseniate of soda. It consists of

Arsenic acid	42.94	100
Baryta	57.06	132.88

100.

Sub-arseniate of Lead, made by double decomposition, was found to contain

Arsenic acid	25.25	100
Protoxide of lead	74.75	296.04

100.

And *arseniate of Lead*, to consist of

Arsenic acid	34.14	100
Protoxide of lead	65.86	192.91

Hence, in the sub-salt, arsenic acid is united with one and a half times as much base as in the neutral arseniate of lead.

ADDITIONS TO THE SECTION ON COBALT.

Composition of the Oxides of Cobalt.—Vol. II. p. 125.

PROTOXIDE of Cobalt is composed,

	Metal.	Oxygen.	Metal.	Oxygen.
According to Rolhoff, of . . .	79.56 .	21.44 . .	100 . .	27.3
Thomson			100 . .	28.5
Brande			100 . .	24.7

The Peroxide consists,

	Metal.	Oxygen.	Metal.	Oxygen.
According to Rolhoff, of . . .	71 . .	29 . . .	100 . .	40.85

Rolhoff ascertained that 100 parts of peroxide of cobalt, exposed to a strong heat, lose from 9.5 to 9.9. Taking the mean, 9.7, we have 100 of the peroxide composed of 9.7 oxygen + 90.3 protoxide, the oxygen in which, according to the same authority, is 19.3. Therefore $9.7 + 19.3 = 29$, is the oxygen in 100 of the peroxide; or 100 of the metal condense 40.85 oxygen. Hence the peroxide contains $1\frac{1}{2}$ times as much oxygen as the protoxide. Assuming then the protoxide to consist of 1 atom of metal, + 1 atom of oxygen, the equivalent number for cobalt will be very nearly 30; for the protoxide 38; and for the peroxide 42. The anomaly of the fractional atom in the peroxide, may be got over by doubling the atom of cobalt, and considering the protoxide as 1 metal + 2 oxygen, and the peroxide as 1 metal + 3 oxygen; but in that case, the true protoxide, consisting of an atom of each element, must be supposed to be unknown. The subject, indeed, appears to require further elucidation from experiment.

Description of Several Salts of Cobalt.—Vol. II. p. 126.

Sulphate of Cobalt.—Sulphuric acid does not attack cobalt unless when concentrated and heated; nor does it readily dissolve the

oxide. They may, however, be brought to combine, and the result is a salt in small red prismatic crystals, composed, according to Dr. Thomson, of

Sulphuric acid	54.08 . . .	100
Protoxide of cobalt	45.92 . . .	85

100.

Nitrate of Cobalt.—The crystals of this salt are small prisms of a red colour. They are deliquescent in the air, and decomposable by heat, leaving a deep red powder.

Phosphate of Cobalt is formed by mixing muriate of cobalt and phosphate of soda. A lilac precipitate falls, which, if mixed with eight parts of fresh precipitated alumina, and dried, forms, according to Thenard, a blue pigment that may be substituted for *ultra marine*.

ADDIOTINS TO THE SECTION ON MANGANESE.

Purification of the Black Oxide of Manganese.—Vol. II. p. 127.

THIS substance is by no means a pure oxide of manganese, for, besides carbonate of lime, which is occasionally present in it, it contains also oxides of iron, copper, and lead, and sometimes a small quantity of baryta. To purify it, equal parts of manganese and sulphuric acid may be heated together, till the vapour of sulphuric acid ceases to appear. A solution of the residuum can of course contain neither baryta nor lead, and consists only of the sulphates of manganese, iron, and copper. To remove the two latter metals, pass sulphuretted hydrogen through the solution, and then concentrate it by evaporation. Spirit of wine, containing from 80 to 90 per cent. alcohol, divides the solution into two parts, the lower of which soon deposits sulphate of manganese; and from this, carbonate of potassa precipitates carbonate of manganese, capable of yielding all the different oxides of that metal.

Mr. Faraday has employed a simpler process for obtaining oxide of manganese in solution, without any other metal. It consists in heating excess of common black oxide with muriate of ammonia in a crucible. The chlorine, which is disengaged, seizes the manganese in preference to any other substance; and, on adding water and filtering, a pure solution of muriate of manganese is obtained. No iron, copper, or other metal, is taken up so long as any spare oxide of manganese is present. From the solution, bi-carbonate of potassa throws down a pure carbonate, from which the carbonic acid may be expelled by heat. (*Quarterly Journal*, vi. 358.) If iron be already in a state of solution in sulphuric or muriatic acid, along with manganese, the two metals may easily be separated, as Mr. Hatchett has shown, by ammonia, which throws down the oxide of iron, but forms with the manganese a soluble triple salt.

Oxides of Manganese.—Vol. II. p. 128.

An able investigation of the oxides and salts of manganese was published by Dr. Forchhammer in 1820, in an Inaugural Dissertation, "*De Mangano*," of which an abstract may be found in the *Annals of Philosophy*.

1. To obtain the *protoxide*, a glass tube, open at both ends, was filled with deutoxide, and heated over a lamp, while hydrogen gas was passed through it. The brown powder soon changed to a light yellow, which colour, while the powder was cooling, became white, and the powder when cold was of a beautiful light green. Its colour, however, soon changed by exposure to the air, and when heated below 600° , it was re-converted into deutoxide, burning slowly with a reddish light.

2. The *deutoxide*, according to the same author, may be obtained by exposing the pure carbonate of manganese, during a long time, to a red heat in an open vessel; or by triturating peroxide of manganese with binoxalate of potassa and water, a pink solution is obtained, from which ammonia throws down the deutoxide. Its colour is brown, resembling that of deutoxide of iron, but rather darker. It is soluble in concentrated muriatic acid at 42° Fahr.; but, if the temperature of the solution be at all raised, or if it be exposed to the sunbeams, chlorine escapes, and muriate of protoxide is formed. The existence of the deutoxide has been doubted, but, in fact, it is, Dr. Forchhammer asserts, the only one which is easily obtained in a pure state.

3. When the deutoxide is boiled with weak nitric acid, a portion of it parts with oxygen, and enters into solution in the state of protoxide, while the remainder is converted into *peroxide*, which is black, and insoluble in all acids, except such as deprive it of oxygen. The native ore of manganese is, when pure, identical, in its chemical properties, with this oxide, except that it is contaminated with other oxides. It is found in great abundance in Devonshire, Warwickshire, &c.

The following table shows the composition of these oxides, according to Dr. Forchhammer's analysis.

	Metal.	Oxygen.	Metal.	Oxygen.
Protoxide (green)	76.27 . . .	23.73 . . .	100 . . .	31.25
Deutoxide (brown)	70.403 . . .	29.597 . . .	100 . . .	42.040
Peroxide (black)	63.749 . . .	36.351 . . .	100 . . .	62.50

It is obvious, therefore, that the peroxide contains twice as much oxygen as the protoxide; but the artificial peroxide, dried at a low heat, is a hydrate containing 16 oxygen, 30 manganese, and 9 water.

The discordance among the results of different analysts, as to the composition of the protoxide, prevents us from deducing, in this way, the weight of the atom of manganese. Dr. Thomson, from the composition of the sulphate, infers the equivalent number of manganese to be 28; to agree with which 100 parts of metal should unite with 28.5 oxygen; and in the peroxide, the oxygen should therefore be $28.5 \times 2 = 57$ on 100 of the metal.

Nature and Composition of Chameleon Mineral.—Vol. II. p. 131.

WHEN the crystals of chameleon mineral are heated in contact with hydrogen gas, they cause it to inflame. They detonate violently with phosphorus; and set fire to sulphur, arsenic and antimony, and indeed to all combustible bodies hitherto tried. The red compound was supposed to be a neutral *manganesiate of potassa*, and the green, a *sub-manganesiate*; but it seems more probable, from the experiments of Forchhammer, that the difference between the red and green compounds depends, not on the quantity of potassa combined with the oxide of manganese, but on the proportion of oxygen united with the manganese itself. Conformably with this view, he found that adding alcohol or carbonate of manganese to the red compound changed it to green by abstracting oxygen. The manganese in the latter compound, he considers as forming an acid with a minimum of oxygen; the proportions being 100 metal and 96.847 oxygen, constituting *manganeseous acid*; the green salt, therefore, is a *manganesite* of potassa. The red compound, he states, contains an acid which may be called the *manganesic*, and its compounds *manganesiates*. In this acid 100 of metal are united with 132 of oxygen, which corresponds very nearly with the proportion of one atom of metal = 28, to 5 of oxygen = 40. In the constitution of the manganeseous acid no such coincidence can be discovered between theory and the results of experiment. Though it is extremely probable, therefore, that manganese is capable of forming one or more true acids with oxygen, yet the proportion of the elements of these acids may be considered as still undetermined.

ADDITIONS TO THE SECTION ON CHROMIUM.

Process for obtaining Chromic Acid and Chromium from Chromate of Iron.—Vol. II. p. 132.

CHROMATE of iron, from the greater plenty in which it is found, is a much cheaper source of chromic acid than the red lead ore of Siberia. After reducing it to fine powder, it is to be mixed with half its weight of nitrate of potassa, and heated strongly for an hour or two in a crucible. The mass is to be repeatedly digested with water, and the coloured liquids, which are slightly alkaline, saturated with nitric acid, and concentrated by evaporation, till no more crystals of nitre can be obtained from them. The yellow liquid, being now set aside for a week or two, deposits a copious crop of yellow crystals in small needles. These are to be separated, dissolved in water, and crystallized over again. They are then sufficiently pure chromate of potassa. From the solution of these crystals, or indeed from the yellow liquid, nitrate of mercury throws down a red powder, which is chromate of mercury. When sufficiently heated, this compound is decomposed, and yields chro-

mic acid or chromic oxide, from either of which metallic chromium may be obtained, by heating it violently with charcoal in a crucible.

Chromic Acid, and Salts containing Chromium.—Vol. II. p. 132.

Chromic acid may be obtained, by mixing nitrate of baryta with chromate of potassa. Chromate of baryta is formed, and may be decomposed by adding its equivalent of sulphuric acid. It is of a red colour, and may be obtained from its aqueous solution in ruby-coloured crystals. It has a sour metallic taste. When ignited, it parts with oxygen, and becomes the green protoxide.

Chromate of Potassa crystallizes in four-sided slender prisms, terminated by dihedral summits. Their colour is an intense lemon-yellow, with a slight shade of orange. The colouring power of this salt is so great, that 1 grain in 40,000 grains of water forms a solution which is perceptibly yellow. Its taste is cooling, bitter, and very disagreeable, remaining long in the mouth. One hundred parts of water at 60° dissolve about 48 parts, but boiling water dissolves almost any quantity. It is insoluble in alcohol. Its solution in water decomposes most of the metallic salts; those of lead of a beautiful yellow colour, now much used as a pigment; those of mercury of a fine red; copper and iron reddish-brown; silver, dark red. According to Dr. Thomson, who has lately investigated it with much care, chromate of potassa is composed of

1 atom of chromic acid	=	52
1 do. of potassa . . .	=	48
		<hr/>
		100

Bi-chromate.—When to a solution of these crystals in water, such a quantity of sulphuric acid is added, as to give the liquor a sour taste, and it is set aside for 24 hours, small regular needles are deposited; or sometimes rectangular tables of considerable size, and of a beautiful orange-red colour. These crystals are the *bi-chromate of potassa*. They are much less soluble in water than the chromate; for 100 parts at 60° Fahr. dissolve only about 10 parts. The solution has an intense orange colour, and reddens vegetable blues. This salt is composed of

2 atoms of chromic acid	=	104.	. . .	68.421
1 atom of potassa . . .	=	48.	. . .	31.579
		<hr/>		<hr/>
		152		100.

Carbonate of Chromium is of a brown colour. Boiling water decomposes it into carbonic acid and green oxide.

The chromates of ammonia, potassa, soda, lime, and magnesia, are soluble and crystallizable, and are all of an orange colour.

Those of baryta and strontia are with difficulty soluble. The combination of chromic acid with various bases, and the properties of the resulting salts, have been fully described by Vauquelin, in the 70th volume of *Ann. de Chim.*; by Dr. John in the 4th volume of the *Annals of Philosophy*; by Dr. Thomson in the 16th volume of the same work; and by Grouvelle in the 17th volume of *Annales de Chim. et de Physique*. It appears to be doubtful whether any compounds exist that can properly be called *chromites*.

Equivalents of Chromium and its Oxides.—Vol. II. p. 133.

THE composition of the oxide and acid of chromium has not been determined by direct experiments; but from the analysis of chromates of lead and baryta, it would appear that 52 is the equivalent number for chromic acid. Now Berzelius assigns to the acid double the quantity of oxygen that exists in the oxide, and it is probable that chromic acid consists of one atom of metal + 3 atoms of oxygen. Deducting 24 from 52, we obtain 28 for the atom of chromium, and $28 + 12 = 40$, for that of the protoxide.

The principal use, to which chromium has been applied, is the preparation of the beautiful pigment, chromate of lead, known in commerce by the name of *chrome yellow*. It is prepared by mixing the solutions of chromate of potassa and nitrate or acetate of lead. Nineteen parts of bi-chromate of potassa decompose 41.5 of dry nitrate of lead. The insoluble compound consists of 1 atom of chromic acid + 1 atom of protoxide of lead. (Thomson.) It appears probable, also, from the experiments of Lassaigne, (*Ann. de Ch. et Ph.* xiv. 299, xv. 76, and xvi. 400), that chromium admits of being successfully applied to the arts of dyeing and calico-printing; and in the latter very striking effects have already been produced on the large scale.

ADDITION TO THE SECTION ON URANIUM.

Composition of the Oxides of Uranium.—Vol. II. p. 135.

ACCORDING to the experiments of Schöubert (Thomson's *Chemistry*, i. 427) the composition of the protoxide of uranium, deduced from the analysis of the muriate, is 100 metal + 6.373 oxygen; and the multiple of the oxygen in the peroxide, being, according to the same authority $1\frac{1}{2}$, we have 100 metal, + 9.569 oxygen for the composition of the peroxide. This would make the weight of the atom of uranium 125, of the protoxide 133, and of the peroxide 137. But from a series of experiments which are described in the *Quarterly Journal*, xix. 88, it seems probable that 72 may be the equivalent number. The subject, however, still remains in considerable uncertainty, and more especially as the analyses of its salts, as

there stated, afford equivalent numbers that do not coincide with each other.

ADDITION TO THE SECTION ON TUNGSTEN.

Oxide and Sulphuret of Tungsten.—Vol. II. p. 136.

Oxide of Tungsten.—When hydrogen gas is passed over ignited tungstic acid, a chocolate powder is obtained, which neither combines with acids nor with bases. Berzelius finds it to be an oxide, the oxygen in which is to that in the acid in the proportion of 2 to 3. (Ann. de Chim. et Phys. xvii. 16.) Therefore in this compound, 96 of metal are united with 16 of oxygen very nearly. Tungstate of lime was found by Klaproth to consist of 77.75 acid + 22.25 lime; but Berzelius states its components to be 80.4 acid + 19.6 base. This is the composition also of Wolfram, so far as respects the tungstate of lime in that mineral.

Sulphuret of Tungsten.—Berzelius has lately examined also the sulphuret of tungsten, with the view to determine the capacity of saturation of that metal. He heated together one part of powdered tungstic acid, and four of sulphuret of mercury. The latter metal was expelled, and a blackish-gray compound remained, not unlike sulphuret of copper. On analysis, it afforded

		Atoms.	
Tungsten . .	74.891 . .	100. . .	1 . . = 96
Sulphur . . .	25.109 . .	35.53 . .	2 . . = 32
	<hr/>	100.	<hr/>
			128

One hundred parts of the sulphuret, calcined so as to expel the sulphur and oxidize the metal, gave 93.5 of tungstic acid; and, as that quantity of acid must contain 74.891 metal, 100 should contain 80.09, which agrees with the experiment of Bucholz. It may be remarked, that the sulphur in the sulphuret is rather more than double the oxygen in the new oxide obtained by Berzelius; but the difference is not greater than may be accounted for by the unavoidable errors of the experiments. Consisting of two atoms of sulphur and one of metal, it is in fact to be considered as a bi-sulphuret of tungsten.

ADDITION TO THE SECTION ON TITANIUM.

Composition of the white Oxide of Titanium.—Vol. II. p. 138.

MR. ROSE, of Stockholm, has attempted to analyze the white oxide of titanium by converting it into a sulphuret. Passing sulphuret of carbon over this oxide, ignited in a porcelain tube, he obtained a grayish-yellow mass, bordering on green. From the ana-

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lyses of this compound, he deduces that the white oxide of titanium contains 33.93 hundredths of its weight of oxygen. This oxide, he observes, does not possess any of the characters of a salifiable base. It dissolves in water, reddens vegetable blues, and expels carbonic acid from carbonates. (Quarterly Journal, xiii. 226.) In these qualities, it approaches to the nature of an acid. In the present state of our knowledge of titanium, it would be premature to attempt to deduce its equivalent.

ADDITIONS TO THE CHAPTER ON VEGETABLE SUBSTANCES.—PART I. CHAP. XX.

Improved Process for the Ultimate Analysis of Organic Substances.—Vol. II. p. 143.

THE object of these improved processes, which are equally applicable to vegetable and animal substances, is to convert the whole of the carbon into carbonic acid, and the whole of the hydrogen into water, by means of some compound containing oxygen in so loose a state of union, as to give it up to those bases at the temperature of ignition. The following illustrations are intended to explain the rationale of the process.

1. If we have charcoal only, mixed with incombustible matter, and wish to determine its quantity, all that is necessary is to expose a known weight of the substance under examination, in a state of perfect mixture with a fit oxide, to a red heat, and to collect the carbonic acid. From the volume of this gas, its weight may be easily calculated; and of this weight, six parts in 22 are pure carbon.

2. Let us next suppose that we are operating on a compound of charcoal with hydrogen. This, if solid, must be mixed with an excess of the oxidated substance which is employed, and the carbonic acid collected as before. Calculating, by the same method, the quantity of charcoal which it contains, we obtain the weight of one element of our unknown compound; and this, deducted from the weight which was submitted to experiment, gives the weight of the remaining element, hydrogen. To attain greater certainty, the water, which is formed, may be actually collected, by a proper addition to the apparatus, either at the same operation with the carbonic acid, or at another, performed expressly for the purpose. Of this water, one part in nine is hydrogen. The carbon, calculated from the carbonic acid, and the hydrogen from the water, should together make up precisely the weight of the compound on which we have operated.

3. A third case may be supposed, in which carbon and hydrogen are united with oxygen, but yet not with enough to convert them entirely, at a high temperature, into carbonic acid and water. In this case, the first steps of the operation are the same as before. But on summing up the results, the weight of the carbon and hy-

drogen, discovered in the products, will be found to fall short of the weight of the substance submitted to experiment. If no other product has been formed, beside water and carbonic acid, the deficiency may safely be placed to the account of oxygen. For example, if from 10 grains of a supposed compound of hydrogen and carbon we obtain, by ignition with an oxide, 22 grains of carbonic acid and 9 grains of water, these are equivalent to 6 grains of carbon and 1 of hydrogen: but $6 + 1 = 7$ leave a deficiency of 3 grains, which may be inferred to be oxygen. To verify this conclusion, if at all doubtful, it may be proper to examine what quantity of oxygen has been lost by the oxide employed to effect decomposition; and if this fall short of the oxygen contained in the carbonic acid, and in the water, then the quantity required to make up the sum, must have previously existed in the subject of analysis. For instance, in the supposed case, we find 16 grains of oxygen in the carbonic acid and 8 in the water obtained, together 24; but if the oxide can be shown by experiment, to have lost only 21 grains, we may safely conclude that 3 grains pre-existed in the compound.

4. In a few vegetable substances, and in almost all animal ones, beside carbon, hydrogen, and oxygen, azote or nitrogen exists as a component, and its quantity requires to be determined. With a proper attention to the details of the process, this fourth element may be obtained in the state of a gas, which remains after absorbing the carbonic acid by solution of potassa, and the oxygen (if any) by a fit agent. From the volume of the gas, its absolute weight may be easily calculated.

Such is an outline of the process employed for the decomposition of vegetable and animal substances, divested of all details for the purpose of rendering its objects and results more intelligible. These details, however, are of considerable importance in practice, and will, therefore, be presently stated at length. It may be proper, however, first to remark, that all the analyses which have been thus performed, and which are worthy of confidence, conspire to prove, that the elements of organized, like those of inorganic matter, are united in definite proportions; and farther, that the law of simple multiples holds strictly with respect to the elements of organic bodies. We may derive, therefore, as has been well observed by Dr. Prout, the most valuable assistance in our researches into organic compounds, from the use of Dr. Wollaston's scale of chemical equivalents. To fit it for this purpose, he recommends that it be extended a little, by pasting two slips of drawing paper on its edges, of such a breadth as just to lap over and cover the margins containing the names of the chemical substances generally marked upon it, and to coincide with the graduated edges of the slide. On these slips of paper are to be marked the multiples of an atom of oxygen, hydrogen, and carbon, from one to ten; and of azote from one to four or five or more. Thus prepared, it will be easily applied, by all who are acquainted with the principle of the instrument, to the purposes of facilitating and verifying analyses, the results of which can only be correct when they agree with some of the proportional numbers, marked upon the scale. For example, an

analysis showing 48 parts of oxygen, 6 of hydrogen, and 36 of carbon, in a vegetable compound, or quantities proportional to these, agrees with 6 atoms of each of those elements. But such an alteration of any of those numbers as would indicate the fraction of an atom (the reduction of the carbon, for instance, to 34) would be inconsistent with the law of simple multiples, and would suggest the necessity of a fresh appeal to experiment.

The agent, first employed by Gay-Lussac and Thenard in the combustion of organic substances, was the *chlorate of potassa*, applied by means of an ingenious apparatus, which is described in the second volume of their *Recherches Physico-chimiques*, and also in Mr. Children's translation of Thenard on Chemical Analysis. For chlorate of potassa, Gay-Lussac afterwards substituted the *peroxide of copper*, which, being found to afford more accurate results, with a less complicated apparatus, and fewer difficulties of manipulation, is now generally preferred, especially in the analysis of animal compounds. Peroxide of copper may be prepared for this purpose by calcining on a muffle the scales or filings of that metal, pulverizing them repeatedly, and again spreading them on the muffle; or by calcining the nitrate of copper at a low red heat. Several variations in the method of proceeding have been recommended by different experimenters. The tube, for containing the mixture of the oxide and body to be analysed, is by some preferred of copper, by others of glass; and the heat has been applied, either by encompassing the tube with burning charcoal, or with the flame of a spirit lamp. Glass tubes of about one-third of an inch bore, or of a diameter adapted to the quantity operated upon, seem, on the whole, to be preferable to metallic ones; and the heat of a spirit lamp, used in the most improved manner, appears to me adequate to effect a complete decomposition of most vegetable and animal compounds.

If the substance be a solid, from 3 to 5 grains carefully dried, (which is best done by placing it in fine powder under an exhausted receiver along with sulphuric acid,)* are to be triturated in a glass or porphyry mortar, first by themselves, and then with 120 to 200 grains of the peroxide of copper, added by degrees, so that the substance and the oxide may be thoroughly incorporated. This mixture must be transferred, with the most scrupulous care to avoid loss, into the glass tube, and a little more of the peroxide must be triturated in the mortar, to collect any remains of the substance under analysis, and then added to the contents of the tube. Over these, 20 or 30 grains of the peroxide may be placed; and the remainder of the tube may be filled with perfectly dry amianthus. The peroxide should either have been recently cooled from a state of ignition, or, as advised by Dr. Ure, have been suffered to imbibe all the moisture it is capable of absorbing from the air, and assayed for the quantity, which, in that case, must be deducted from the loss of weight, sustained by the peroxide in the experiment. To operate on a fluid, Dr. Ure incloses it in a small glass bulb capa-

* An apparatus for drying substances in vacuo, at a temperature of 212° Fahrenheit, is described by Dr. Prout in Ann. of Phil. vi. 272.

Two square upright pillars are morticed into a square tray (*a a* at the bottom of the figure) about 3-4ths of an inch deep, and are fixed at the top by brass screws into a flat shelf of wood, 3 inches broad at each end, and 5 in the middle, in which is an oval slit or hole $4\frac{1}{2}$ inches long and $1\frac{1}{4}$ wide, distant $1\frac{1}{2}$ inches from the right hand extremity of the shelf. Below this is another shelf, *b b*, which is moveable by a rack and pinion worked by a small handle, as shown at *f*. Into a shallow cavity in this shelf is fixed a cistern of copper covered with hard varnish, (cast iron would be better) and having a deep cylindrical cavity or well at *d*. This, to economize mercury, may occasionally be filled with a plug of wood or cast iron. The cistern may be of any convenient dimensions, as $5\frac{1}{2}$ long by $1\frac{1}{2}$ wide, and in its bottom, an opening is required about 5-8ths of an inch diameter for admitting the glass tube *g g*, which is secured in its place by a perforated cork, and is passed also through the axis of a brass spirit lamp, which, as well as the wick, has a circular hole for the purpose. The lamp is placed on a small shelf, perforated also, and moveable by the rack and pinion. A small mirror of tin, with the concave side downwards, is screwed to the bottom of the cistern, to guard the cork from being burned by the heat of the lamp. At *k* is a turning button with a semicircular notch for securing in an upright position the jar *h*, which should be capable of containing 7 or 8 cubical inches.

The tube *g g* being fixed in its place, and the jar *h* filled with and inverted in mercury, the spirit lamp is set as high as its carriage will permit, and lighted. The part of the tube, which is surrounded by the burning wick, soon becomes red hot, and gas is evolved. When it ceases to issue, the lamp may be gradually lowered, so as to heat successively the whole of the tube, and then moved upwards to the top. When this has been skillfully performed, the whole of the substance under analysis will be found to have been decomposed; but to insure accuracy, its contents may be taken out, triturated in a mortar, and subjected to a repetition of the same operation. The gases obtained must be exposed to the action of liquid potassa, which will absorb the carbonic acid. In measuring the residue, it will be necessary to equalize the level of the mercury within and without the receiver, by immersing it in the well *d*. The residuary gas will probably be nitrogen only, but it may be assayed for oxygen by nitrous gas. The gases must of course be either measured at a mean of the barometer or thermometer, or the proper corrections made for deviations from these standards, as well as for aqueous vapour.

To collect the water, a separate operation on another portion of the substance is necessary. When this is done, the mercurial cistern may be removed; and such a condensing apparatus substituted, as will be obvious to persons conversant with chemical processes.

By the apparatus of Dr. Prout, a part only of the tube and its contents can be heated at once. This is of little consequence when solid bodies are acted upon; but in the decomposition of liquids,

or of solids yielding liquid products, it is desirable to ignite a greater length of the tube at a time. To effect this, Mr. Cooper, of Lambeth, employs a lamp, which appears to me very well adapted to the purpose, and which he permits me to mention. It is of tin, in the shape of a parallelopipedon, 8 inches long and $1\frac{1}{4}$ square, with 5 flat wick-holders, fixed at equal distances and at a small angle with its upper surface, each wick-holder being half an inch broad and $\frac{3}{8}$ ths of an inch high. Of these lamps two are necessary, and they are placed in a small tin tray which is raised on four feet, and has a longitudinal slit in the middle $7\frac{3}{4}$ inches long and $\frac{3}{8}$ ths of an inch wide. On this tray the lamps are placed with their wicks opposite to each other; and the tube, containing the mixture to be decomposed, which is of green glass, sealed hermetically at one end, from 10 to 14 inches long, and about the diameter of a small quill, is placed horizontally over the wicks at a suitable distance, one end of the tube having been first bent by a lamp into such a form, that its open extremity can be placed under a jar inverted in mercury. It is easy, as Mr. Cooper was so good as to show me, by lighting one or more wicks, and altering the distance of the flames from the tube, and of the lamps from each other, to modify the application of the heat as the circumstances of the experiment may require. The alcohol, to prevent its too rapid combustion, Mr. Cooper dilutes with water to the sp. gr. of about .860.

It would not be difficult to combine, in one apparatus, the advantages of Dr. Prout's method of operating with those of Mr. Cooper's mode. To effect this, the open extremity of the tube, placed horizontally over the wicks of the spirit lamps, might be admitted into the hole at the bottom of the mercurial cistern. The only disadvantage of this method of proceeding would be that the open extremity of the distilling tube being bent, the contents of the tube could not be got out, for a second trituration and ignition, without breaking it, an inconvenience which does not exist when a straight tube is employed as in Dr. Prout's apparatus.

Those, who prefer employing the heat of charcoal, will find the description of an apparatus, contrived by Dr. Ure for that purpose, in the Phil. Trans. for 1822, p. 460. From observation, however, of the effects of the heat obtained by the combustion of alcohol, it appears to me fully sufficient, with the advantage of being much more manageable than that of a charcoal furnace.

The whole of the operations, connected with the ultimate analysis of vegetable and animal substances, require considerable skill; and some practice in them is necessary to enable a person, who is even conversant in the general processes of chemistry, to obtain accurate results. A single experiment should never be depended upon; but the analysis of each substance should be several times repeated, and a mean taken of those which do not present any very striking disagreement, excluding those results which vary so much from the average, as to lead to a suspicion of some failure in the manipulations.

It may sometimes perhaps, on a first view, excite suspicion of the competency of these methods of ultimate analysis to afford accurate results, when we remark the very near coincidence not only with respect to the *kind*, but even to the *proportions* which have been thus deduced, of the elements of substances, differing essentially as to their chemical and sensible properties. In the instances of gum, sugar, and starch, the differences of composition, discovered by the experiments of Gay-Lussac and Thenard, are so extremely small, as not to indicate any difference either of the kind or the number of elementary atoms. The results, however, are not, in this or similar cases, to be pronounced, for that reason only, to be inaccurate; for it is probable that in vegetable substances, it is not only the *number* and *kind* of the respective atoms, but the *mode of their arrangement*, which occasions their distinctive characters. This view of the subject is confirmed, when we observe the important changes in the properties of vegetable substances, and the convertibility of those, which appear so nearly allied, into each other, by slight causes, such as alterations of temperature, or weak chemical agents.

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Atomic Constitution of Gum.—Vol. II. p. 148.

THE atomic constitution of gum has been investigated in two different ways. On the supposition that the gummate of lead is composed of two atoms of oxide of lead and one of gum, which Dr. Thomson thinks most probable, the atomic constitution of gum will be as follows:

Carbon	6 atoms . . .	36 . . .	40.
Oxygen	6 ditto . . .	48 . . .	53.34
Hydrogen	6 ditto . . .	6 . . .	6.66
		90	100.

If the determination of Dr. Ure, founded on its ultimate analysis, be correct, the constitution of gum should be

Carbon	4 atoms . . .	24 . . .	35.294
Oxygen	5 ditto . . .	40 . . .	58.823
Hydrogen	4 ditto . . .	4 . . .	5.883
		68	100.

In the first case, which agrees most nearly with the results of its ultimate analysis by Berzelius, the weight of the atom of gum would be 90; in the second, 68. But as Dr. Ure acknowledges that the gum, which he submitted to experiment, had not been artificially dried, and, therefore, contained hygrometric moisture, it is probable that the statement of its constitution is most correct, which is founded on those analyses that assign the larger propor-

tion of charcoal. The nitrogen found by Saussure, not being present in any proportion amounting to an atom, may be regarded as probably accidental. To determine this point, however, the quantity of ammonia should be ascertained, which passes over in combination with acetic acid, when gum is submitted to destructive distillation; and in any fresh analysis of gum, by combustion with chlorate of potassa or peroxide of copper, it will be desirable to examine the gaseous products with an especial view to the presence of nitrogen.

Atomic Constitution of Sugar.—Vol. II. p. 151.

On comparing the results of the analysis of sugar by different persons, the principal deviation appears to exist in those of Dr. Prout, which indicate less charcoal and more oxygen than the rest. If reduced to atomic proportions, his experiments (respecting which some details are given in the *Annals of Philosophy*, N. S. iv.) point out the following as the composition of sugar :

Charcoal . . . 5 atoms . . .	30 . . .	40.00
Oxygen 5 ditto . . .	40 . . .	53.34
Hydrogen . . . 5 ditto . . .	5 . . .	6.66
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	75	100.

The atomic proportions, approaching most nearly to the other results, are

Charcoal . . . 6 atoms . . .	36 . . .	44.44
Oxygen 5 ditto . . .	40 . . .	49.38
Hydrogen . . . 5 ditto . . .	5 . . .	6.18
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	81	100.

If deduced from the compound of sugar with oxide of lead, on the supposition that this compound consists of an atom of each ingredient, the constitution of sugar will agree precisely with the latter statement, a coincidence which strengthens the probability that it consists of 6 atoms of charcoal, 5 of oxygen, and 5 of hydrogen, and that 81 is its true representative number.

Means of distinguishing Oxalic Acid from Epsom Salt.—
Vol. II. p. 152.

OXALIC acid is a most virulent poison, and has frequently proved fatal, when taken by mistake for Epsom salt. From that salt, however, it may readily be distinguished, though not from other acids, by carefully tasting it in the smallest quantity sufficient for the purpose, when its sourness will be distinctly perceived. Or, with-

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out tasting it, if a few drops of water be placed on a slip of the dark blue paper, which is commonly wrapped round sugar loaves, and a small quantity of any substance suspected to be oxalic acid be added, that acid will be discovered by its changing the colour of the paper to a reddish-brown. The solution also of a small quantity of oxalic acid in a tea-spoonful of water, will effervesce with a little scraped chalk or common whiting; but neither of these effects is produced by Epsom salt.

Atomic Constitution of Oxalic Acid, both Crystallized and Anhydrous.—Vol. II. p. 152.

DR. THOMSON, from his recent experiments, (Ann. of Phil. N. S. ii. 136), is led to consider the crystals of oxalic acid as composed of equal weights of water and anhydrous acid, or of

1 atom of acid	36
4 atoms of water	36
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	72

The analysis of oxalic acid by combustion with chlorate of potassa was performed by Gay-Lussac and Thenard, and with peroxide of copper by Berzelius and Dr. Ure. The following table exhibits their different results; those of Gay-Lussac and Thenard being corrected in the second column to exclude the water, which appears to have entered into the oxalate of lime, employed in their experiment, in such proportion as to have been equal to one-fifth of its acid ingredient.

Carbon	26.566 . . .	33.217 . . .	33.222 . . .	33.33
Oxygen	70.689 . . .	66.290 . . .	66.534 . . .	66.66
Hydrogen . .	2.745 . . .	0.493 . . .	0.244	
	100.*	100.†	100.‡	100.§

The quantity of hydrogen in oxalic acid, deprived of water by combination with oxide of lead, is so extremely small, as not to amount to any atomic proportion. Dobereiner, indeed, appears to have been the first to suggest, about the year 1815, that hydrogen is not an element of anhydrous oxalic acid, but that it is constituted of carbon and oxygen only; and he has added fresh evidence in favour of this view of its nature, in a short paper published in the Ann. de Chim. et de Phys. xix. 83. From the results of its analysis, considered in connexion with the proportions in which it combines with bases, it appears extremely probable that oxalic acid consists of

* Gay-Lussac and Thenard.

† Berzelius, Ann. of Phil. v. 99.

‡ Ditto. corrected.

§ Ure, Phil. Trans. 1822, 480.

Carbon	2 atoms . . .	12 . . .	33.34
Oxygen	3 ditto . . .	24 . . .	66.66
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		36	100.

Or it may be regarded as constituted of

Carbonic acid	1 atom =	22
Carbonic oxide	1 ditto =	14
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		36

Account of Various Oxalates.—Vol. II. p. 153.

Oxalate of Potassa.—[For a description of it, see body of the work, vol. II. p. 153.]

Binoxalate of Potassa forms small white parallelopipeds or rhomboids approaching to cubes. It has a pungent acid taste mixed with some bitterness. It requires for solution ten times its weight of water at 60°, and a still larger proportion of boiling water. It may either be formed artificially, or obtained from the juice of the *oxalis acetosella*, or of the *rumex acetosa*. When procured in the latter mode, it is sold under the name of *salt of sorrel*, or *essential salt of lemons*.

Quadroxalate of Potassa forms beautiful crystals, which may be obtained pure by solution and a second crystallization.

If three parts by weight of the quadroxalate be decomposed by burning, and the alkali, which is thus disengaged, be mixed with a solution of one part of the crystallized salt, the latter is exactly neutralized. Hence the quadroxalate contains four times the acid that exists in the oxalate. The analysis of this class of salts, from which Dr. Wollaston (in the Phil. Trans. for 1808) drew a striking exemplification of the law of simple multiples discovered by Mr. Dalton, may be recapitulated as follows:

	Atom of base.	Atoms of acid.	Base.	Acid.	Equivalent Number.
The oxalate consists of	1	+ 1 . . .	48	+ 36 =	84
The binoxalate	1	+ 2 . . .	48	+ 72 =	120
The quadroxalate . . .	1	+ 4 . . .	48	+ 144 =	192

Estimating, therefore, from the weights of their atoms, 100 of potassa should be united, in the oxalate, with 75 of acid; in the binoxalate, with 150; and in the quadroxalate, with 300.

Oxalate of Alumina.—Fresh precipitated alumina is soluble in oxalic acid; but the compound is not crystallizable, forming when evaporated a yellowish pellucid mass. It has a sweetish astringent taste, and is composed of 44 alumina + 56 acid and water.

Oxalate of Manganese.—Oxalic acid, digested with oxide of manganese, is partly decomposed; carbonic acid is disengaged with effervescence, and the manganese, reduced to the state of deutoxide, unites with the oxalic acid. The oxalate of manganese is pre-

precipitated in the state of a white powder, which also appears on adding oxalic acid to the sulphate, nitrate, or muriate of manganese.

Oxalate of Zinc appears on adding oxalic acid to the solution of sulphate, muriate, or nitrate of zinc, from which it throws down the whole of the metallic oxide, in the form of an insoluble oxalate.

Oxalates of Iron.—Oxalic acid unites both with the protoxide and peroxide of iron. The solution of the protoxide affords prismatic crystals of a green colour and sweet astringent taste, soluble in water, and composed of 55 acid + 45 oxide. By exposure to the air, in a liquid state, this salt is changed into *per-oxalate*, which is incapable of crystallizing, and has the form of a yellow powder, insoluble in water. The peroxalate may, also, be formed by the direct combination of oxalic acid with peroxide of iron.

Oxalate of Tin may be formed by the direct action of oxalic acid on tin. The solution yields prismatic crystals, which are soluble in water, and have an austere taste.

Oxalate of Cadmium, formed by decomposing any salt of cadmium with the solution of an alkaline oxalate, is a white insoluble powder.

Oxalate of Antimony is precipitated in small crystalline and insoluble grains, on adding oxalic acid to the solution of antimony in sulphuric acid.

Oxalate of Cerium.—Oxalic acid and oxalate of ammonia precipitate the protoxide of cerium from its solutions, forming a white salt not soluble in an excess of acid, but soluble in liquid ammonia. With the peroxide, the precipitate is of a red colour.

Oxalate of Cobalt is precipitated by oxalic acid from solutions of the metal, in the form of a red powder, insoluble in water without an excess of acid, but then forming a solution which is capable of yielding crystals.

Oxalate of Bismuth may be formed either by decomposing the salts of bismuth with an alkaline oxalate, or by acting on the oxide with oxalic acid. It is a white insoluble powder.

Oxalate of Copper appears in the state of a bluish-green precipitate, when oxalic acid is added to nitrate, acetate, or sulphate of copper.

Oxalate of Lead is best formed, by adding oxalic acid to solution of nitrate, or acetate of lead. It is nearly insoluble in water, unless an excess of acid be present. It is composed according to Berzelius, of 24.54 oxalic acid, + 75.46 oxide of lead, which agrees as nearly as possible with an atom of each of its ingredients, viz. 36 acid + 112 oxide.

Oxalate of Mercury is precipitated by oxalic acid from nitrate of mercury, in the state of an insoluble white powder. This, when exposed to the light, becomes black, and detonates when heated. It enters into the composition of Howard's fulminating mercury.

Oxalate of Silver may be formed by adding oxalic acid to nitrate of silver. Its colour is white, but it is blackened on exposure to the light by the reduction of its oxide.

Atomic Constitution of Citric Acid.—Vol. II. p. 158.

THE constitution of citric acid, most nearly agreeing with the results of Berzelius, is as follows :

Carbon 4 atoms	24	41.38
Oxygen 4 ditto	32	55.17
Hydrogen 2 ditto	2	3.45
	<hr/>	
	58	100.

Dr. Ure's determination gives, for the crystals, 4 atoms of carbon + 5 of oxygen + 3 of hydrogen, and the equivalent number 67, from which, deducting two atoms of water, always detached by uniting the acid with protoxide of lead, (or 2 atoms of oxygen + 2 of hydrogen), he deduces the composition of the anhydrous acid to be 4 atoms of carbon = 24, + 3 of oxygen = 24, + 1 of hydrogen; and its equivalent number, therefore, to be 49. Reasoning from the composition of citrate of lead, Dr. Thomson concludes that the true representative number for dry citric acid is 58, and for the crystals $58 + 18 = 76$. (Ann. of Phil. N.S. ii. 140.) Such a number would result from a combination of 4 atoms of carbon, 4 of oxygen, and 2 of hydrogen. From the united evidence, therefore, of Berzelius's analysis of citric acid, and of the composition of citrate of lead, we may consider the anhydrous acid as correctly represented by 58, and the crystals, containing 2 atoms of water, by $58 + 18 = 76$.

Account of Pyro-citric Acid.—Vol. II. p. 159.

M. LASSAIGNE has given this name to an acid produced by the destructive distillation of citric acid. When citric acid is heated in a retort, it first fuses, and then parts with nearly the whole of its water of crystallization. The liquid products are of two different kinds; the one of an amber colour and oily consistence, occupies the bottom of the vessel; the other colourless and liquid like water, and floating over the former, has a decidedly sour taste. It is found, however, on examining the oily fluid, that, along with its bituminous taste, it has a strongly acid one; and on agitating it with water, and then allowing the mixture to stand, the water when decanted is rendered acid. The oily fluid, left to itself, soon becomes acid again, and deposits white crystals which are also strongly acid. When again agitated with water, only a small portion re-assumes the oily form; or, if kept under water, it is soon acidified.

The colourless liquid and the oily fluid both contain an acid, which has properties differing essentially from those both of the citric and the acetic. It may be obtained pure, by first saturating it with lime, and then disengaging it by oxalic acid; or by decomposing the calcareous salt with acetate of lead, and treating the

precipitate with sulphuretted hydrogen. Its properties are the following:

It is white, inodorous, sour to the taste, and a little bitter; difficult to obtain in distinct crystals, but presenting itself under a white mass, formed by the interlacement of numerous fine needles. It is extremely soluble in alcohol and in water, the latter of which, at 50° Fahrenheit, takes up one-third its weight. It forms salts differing decidedly from those which result from the union of citric acid with the same bases. Its combination with potassa crystallizes in small needles, which are soluble in four parts of water. With lime, it yields a salt in needles, which are disposed opposite to and at angles with each other, like the leaves of fern. These crystals require 25 parts of water at 50° for solution. The pyro-citrate of lime consists of 34 acid, and 66 base, excluding the water, which forms 30 per cent. of the crystals. One hundred parts of the acid are equivalent to neutralize

194.117 parts of lime	
127.272	baryta
203.	protoxide of lead.

It is remarkable then that its capacity of saturation is exactly the same as that of citric acid; but the results of its ultimate analysis, effected by treating pyro-citrate of lead with oxide of copper, gives a perfectly different atomic constitution, viz.

Carbon	47.5
Oxygen	43.5
Hydrogen	9.
	<hr/>
	100.

These results are not very remote from

Carbon	8 atoms	48	49.5
Oxygen	5 ditto	40	41.2
Hydrogen	9 ditto	9	9.3
		<hr/>	<hr/>
		97	100.

Additional Methods of obtaining Gallic Acid.—Vol. II. p. 160.

To separate gallic acid from the tan which accompanies it, Baruel has proposed to add to the infusion of galls a solution of white of eggs, till it ceases to occasion a precipitate; to evaporate to dryness the clarified liquor; and to add alcohol to the dry mass. From the alcoholic solution, the gallic acid may be obtained in crystals by evaporation. (Thenard's *Traité de Chim.* 2d edit. and *Ann. de Chim. et Phys.* x. 235.) Mr. Faraday has adopted a similar process, using gelatin instead of albumen, and applying it by boiling together bruised galls with about one-sixth their weight of clipped

skins. (Quarterly Journal, vi. 154.) All these methods, however, M. Braconnot is of opinion are inferior to that of Scheele, when modified as follows. He infused 250 grammes (each about 15½ grains) of bruised galls in rather more than two wine pints of water during four days, agitating from time to time; pressed out the liquor; filtered it through paper, and exposed the liquor to the air in a glass vessel, at a temperature varying from 65° to 75° Fahrenheit, for two months. A considerable quantity of gallic acid separated in crystals, which were collected and pressed. The solid, thus obtained, consisted partly of gallic acid, and partly of a new acid, insoluble in boiling water. The liquid, which passed through the cloth, was evaporated to the consistence of sirup, and at the end of 24 hours, more crystals were obtained, which were also subjected to pressure. The quantity of gallic acid amounted to 62 grammes, but it was mixed with an insoluble powder. The whole was boiled with about a pint and a quarter of water, and filtered; and about 10 grammes of a light fawn coloured substance remained on the filter. The filtered solution deposited on cooling about 40 grammes of gallic acid, and, from the remaining liquid, about 10 grammes more were obtained by evaporation. M. Braconnot found, also, that gallic acid was developed by keeping the bruised galls moistened and exposed to the air, and that an odour of alcohol was emitted during their decomposition. (Ann. de Chim. et de Phys. ix. 184.)

Braconnot finds that the gallic acid, prepared by his method, and having a light fawn colour, may be purified by dissolving 100 parts in 800 of boiling water, and adding 18 parts of animal charcoal, (ivory black), which has been washed with diluted muriatic acid. The materials are to be kept heated in a sand bath for a quarter of an hour; and the liquor filtered through paper and suffered to cool, agitating it several times. The acid thus obtained is, after pressure, perfectly white, and occasions no precipitate in an infusion of gelatin. Re-dissolved in boiling distilled water, it forms small silky crystals of the most perfect whiteness.

Composition of Gallic Acid.—Vol. II. p. 160.

THE only analysis we possess of gallic acid is that of Berzelius (Ann. of Phil. v. 178.) According to his experiments, it consists of

Carbon	56.64
Oxygen	38.36
Hydrogen	5.

100.

The atomic constitution, most nearly corresponding with these proportions, is the following:

Carbon . . . 6 atoms . . . 36 . . . 57.14	
Oxygen . . . 3 ditto . . . 24 . . . 38.10	
Hydrogen . . 3 ditto . . . 3 . . . 4.76	
	<hr style="width: 10%; margin-left: auto; margin-right: 0;"/> <hr style="width: 10%; margin-left: auto; margin-right: 0;"/>
	63 100.

This agrees very nearly with the equivalent deducible from the composition of gallate of lead, which, according to Berzelius, consists of 173.97 protoxide of lead, + 100 gallic acid; and 173.97 : 100 :: 112 (the equivalent of oxide of lead) : 63.92.

Account of Several Malates.—Vol. II. p. 161.

Malate of Potassa is deliquescent, very soluble, and not crystallizable. The bi-malate forms crystals which are permanent, soluble in water, but insoluble in alcohol.

Malate of Soda resembles very closely in its properties the foregoing salt.

Malate of Lime.—The neutral malate of lime is an insoluble salt, which may be obtained by adding lime-water to a solution of the super-malate. The latter salt is chiefly formed when carbonate of lime is added to malic acid. It has an acid taste; is soluble in water, but not in alcohol; and, when evaporated to dryness, assumes the appearance of gum. Malate of lime is often found in malic acid, and gives it the property of precipitating nitrate of lead.

Malate of Baryta resembles the foregoing salt in its properties.

Malate of Strontia is more soluble than the two foregoing malates; for strontitic water is not rendered turbid by malic acid, which precipitates lime and baryta from water.

Malate of Magnesia forms permanent crystals, soluble in 28 times their weight of water at 60°.

Malate of Alumina is precipitated, in an almost insoluble form, when malic acid is added to salts with base of alumina. Hence Mr. Chenevix proposed this acid as a means of separating alumina from magnesia; but the method has not been generally adopted in practice.

Malate of Iron forms a brown solution which is not crystallizable.

Malate of Lead is immediately precipitated on pouring malic acid into solution of acetate of lead, and on adding acetate of lead to any liquid containing malate of lime. It is soluble in weak nitric acid and acetic acid. According to Mr. Donovan, it is capable either of existing in a neutral state, or of uniting with an excess of either acid or base; but this is not consistent with the experience of Vauquelin. Gay-Lussac (Ann. de Chim. et Phys. vi. 332) suggests that a triple compound probably exists of malic acid with lime and oxide of lead.

The combinations of malic acid with other metallic oxides have not yet been investigated.

Identity of Malic and Sorbic Acids.—Vol. II. p. 162.

By a train of experiments, Braconnot has been led to conclude, that the sorbic acid is essentially the same with the malic; for when divested of all impurities, it exhibited the same properties, and formed with bases precisely the same compounds. The same conclusion has been drawn by Houton Labillardière. The identity of the acid, when obtained from different sources being thus established, it appears to be due to Scheele to distinguish it by the term *malic*, which he originally proposed for it.

Atomic Constitution of Tartaric Acid.—Vol. II. p. 165.

THE most probable atomic constitution of anhydrous tartaric acid appears to be the following:

Carbon . . . 4 atoms . .	24 . . .	36.36
Oxygen . . . 5 ditto . .	40 . . .	60.61
Hydrogen . . 2 ditto . .	2 . . .	3.03
	<hr/>	<hr/>
	66	100.

And the crystals are probably composed of

Anhydrous acid, 1 atom . .	66 . .	88
Water 1 ditto . .	9 . .	12
	<hr/>	<hr/>
	75	100

An additional atom of hydrogen in tartaric acid would be less consistent with the results of its ultimate analysis; though it would better accord with the equivalent number (67) deducible, as will afterwards appear, from the composition of tartrate of lead.

Composition of the Tartrates of Potassa.—Vol. II. p. 165.

TARTRATE of potassa probably consists of

Tartaric acid, 1 atom . .	66 . .	57.90
Potassa . . . 1 ditto . .	48 . .	42.10
	<hr/>	<hr/>
	114	100.

The atomic proportions, most consistent with the relative weights of the acid and base in the bi-tartrate of potassa, are, exclusive of water,

Tartaric acid, 2 atoms . .	132 . .	73.89
Potassa . . . 1 ditto . . .	48 . .	26.11
	<hr/>	<hr/>
	180	100.

In the tartrate, then, we have 100 base + 137.5 acid
 ——— bi-tartrate 100 . . . + 275.

In the bi-tartrate, is found also a quantity of water, which appears essential to the constitution of the salt; for it cannot be separated by heat, without decomposing the acid. Its proportion, indeed, is as nearly as possible that of an atom, for $95.25 : 4.75 :: 180 : 9$, very nearly. We may consider the crystallized bi-tartrate then as constituted of 1 atom of bi-tartrate + 1 atom of water.

—

Account of Several Tartrates.—Vol. II. p. 166.

Tartrate of Soda, formed by saturating tartaric acid with carbonate of soda, crystallizes in fine needles, which are soluble in an equal weight of cold water. On adding a quantity of tartaric acid equal to that in the neutral salt, we obtain an insoluble bi-tartrate of soda.

Tartrate of Ammonia forms polygonal prisms, which have a bitter taste, are very soluble in water, and, on the addition of a farther proportion of tartaric acid, are converted into an insoluble bi-tartrate.

Tartrate of Lime is formed, in the process for preparing tartaric acid, by adding carbonate of lime to a solution of bi-tartrate of potassa. It is white, tasteless, and almost insoluble in cold water, but soluble in 600 times its weight of boiling water, and in most of those acids that form soluble compounds with lime. According to Berzelius, (94 Ann. de Chim. 179), it consists, when dried at a gentle heat, of

Tartaric acid	50.55	. . .	1 atom	. . .	66
Lime	21.64	. . .	1 atom	. . .	28
Water	27.81	. . .	4 atoms	. . .	36
					<hr/>
					100.
					<hr/>
					130

And the anhydrous tartrate of lime will be represented by $66 + 28 = 94$.

Tartrate of Baryta may be formed by mixing a solution of neutral tartrate of potassa with one of muriate of baryta. A compound falls down, which is insoluble in water, but dissolves in acetic acid, and in nitric and muriatic acids. We are unacquainted from experiment with the proportion of its components, but it probably consists of an atom of each element.

Tartrate of Strontia may be formed also by double decomposition. It dissolves in 320 parts of boiling water, and crystallizes from its solution in rhomboidal prisms. According to Vauquelin, it consists of 47.12 acid + 52.88 base.

Tartrate of Magnesia is an insoluble salt, unless an excess of acid be present. It is more saline to the taste than tartrate of lime, and is fusible by heat.

Tartrate of Alumina may be prepared by acting with tartaric acid on fresh precipitated alumina. It is not crystallizable, but, when evaporated, forms a mass resembling gum.

Tartrate of Manganese.—Tartaric acid, when heated in solution with black oxide of manganese, is decomposed, and carbonic acid is disengaged, a colourless solution of manganese being formed.

Tartrate of Zinc, produced by the direct action of tartaric acid on zinc, is a salt of difficult solubility.

Tartrate of Iron may be formed, either directly by acting on metallic iron with tartaric acid, or by mingling solutions of tartrate of potassa, and proto-sulphate of iron. The compound forms lamellar crystals, which are sparingly soluble in water. By exposure to air, they pass to the state of *pertartrate*.

Tartrate of Tin has not been examined.

Tartrate of Tin-and-Potassa may be formed by boiling oxide of tin in solution of bi-tartrate of potassa. It is very soluble, and is not precipitated by alkalis, either pure or carbonated.

Tartrate of Cobalt.—Tartaric acid dissolves oxide of cobalt, and forms a red crystallizable salt.

Tartrate of Bismuth is precipitated as an insoluble white powder from the salts of bismuth.

Tartrate of Copper forms a blue sediment, on dropping tartaric acid into sulphate or muriate of copper.

Tartrate of Lead is best obtained by adding tartaric acid or neutral tartrate of potassa to acetate of lead. It is an insoluble white powder, and is constituted, according to the analysis of Berzelius, of

Tartaric acid . . .	37.5 . . .	1 atom . . .	66
Protoxide of lead	62.5 . . .	1 ditto . . .	112
	<hr/>		<hr/>
	100.		178

Tartrate of Mercury is an insoluble white compound, which becomes yellow by exposure to the light. A triple salt may also be obtained by boiling in water six parts of cream of tartar, and one part of oxide of mercury.

Account of Pyro-tartaric Acid.—Vol. II. p. 165.

WHEN tartaric acid, or bi-tartrate of potassa, is distilled alone in a retort, a large quantity of combustible gas escapes; an acid liquid passes over; and, towards the close of the process, a white sublimate appears, and concretes on the top of the retort. The acid liquor, when evaporated, also deposits crystals, and these, as well as the sublimate, are the *pyro-tartaric acid*. Its taste is extremely

sour; it dissolves readily in water, and furnishes crystals by evaporation; and its crystals, when heated, first melt, and then sublime in a white smoke, leaving no residuum.

The watery solution does not immediately precipitate acetate of lead or nitrate of mercury; but from the former solution, needle-shaped crystals are, after some time, separated. Its compound with potassa immediately decomposes acetate of lead, but does not, like tartrate of the same base, decompose the salts of baryta and lime; nor does it form, with an excess of acid, a difficultly soluble salt.

From these characters, which differ essentially both from those of tartaric and acetic acids, we may probably consider the pyro-tartaric as a distinct and peculiar acid. (See Ann. de Chim. lxiv. 42, or Nicholson's Journal, xxvi. 44.)

Substances containing Benzoic Acid.—Vol. II. p. 167.

BENZOIC acid is found in *storax*, *balsams of Peru and Tolu*, *vanilla*, *cinnamon*, and the urine of several graminivorous animals; and has been shown by Berzelius to be the characteristic ingredient of the acid obtained by the destructive distillation of tallow. Vogel lately met with it, in a crystallized state, between the skin and the kernel of the Tonquin bean, and in the flowers of the *Trifolium melilotus officinalis*. In the latter, Vogel thinks that it is sufficiently abundant to be advantageously extracted for use. (Annals of Phil. xvi. 227.)

Atomic Constitution of Benzoic Acid.—Vol. II. p. 167.

THE most simple view of the constitution of benzoic acid, founded on the analysis of Berzelius, would represent it as constituted of 5 atoms of carbon, + 1 of oxygen, + 2 of hydrogen. But this would not agree with the equivalent deducible from the analysis, by the same chemist, of benzoate of lead, which is composed of 98.61 protoxide of lead, + 100 benzoic acid; numbers to which 112 and 119.64 are proportional. On the supposition, then, that neutral benzoate of lead contains an atom of each ingredient, the equivalent of benzoic acid is 119.64, or, in whole numbers, 120. Now this agrees very well with the following statement of the constitution of benzoic acid:

	Carbon . .	15 atoms . .	90 . .	75
	Oxygen . .	3 ditto . .	24 . .	20
	Hydrogen . .	6 ditto . .	6 . .	5
			<hr/>	<hr/>
			120	100

Dr. Ure, by saturating benzoic acid with solution of ammonia, deduced 116 for the equivalent of that acid, which, according to his view, consists of

Carbon . . .	13 atoms . .	78 . .	67.24
Oxygen . .	4 ditto . .	32 . .	27.60
Hydrogen .	6 ditto . .	6 . .	5.16
		<hr/>	<hr/>
		116	100.

In calculating, however, from the ultimate analysis of the same substance by different persons, it appears to me that in general those results are to be preferred, by which the largest proportion of carbon is indicated; because it is more probable that too little than too much carbonic acid should be found in the products of combustion. In this instance, too, Berzelius remarks that the volatility of the benzoic acid renders it difficult to prevent a small quantity from escaping decomposition.

Account of Several Benzoates.—Vol. II. p. 167.

Benzoate of Ammonia may be obtained in feather-shaped crystals, which are very soluble, and even deliquescent. This salt has been recommended by Berzelius as an excellent re-agent for precipitating iron from its solution, which it throws down of an orange colour, whereas the few other insoluble compounds which this acid forms with the oxides of mercury, tellurium, and copper, are white.

Benzoate of Potassa.—The neutral benzoate forms feather-shaped crystals, which are soluble and deliquescent. With an additional proportion of acid, a bi-benzoate is produced, which crystallizes in small plates and needles. These require ten times their weight of water for solution, redden vegetable blues, and have an acid sweetish taste.

Benzoate of Soda.—Its crystals are larger than those of the similar salt of potassa, and effloresce in the air. They are very soluble in water.

Benzoate of Lime forms white shining crystals, requiring 20 times their weight of cold water for solution, but more soluble in hot water. It exists in the urine of the cow in considerable abundance.

Benzoate of Baryta, crystallizable, and readily soluble.

Benzoate of Strontia, little known, but probably soluble; because benzoate of ammonia does not precipitate muriate of strontia.

Benzoate of Magnesia, crystallizable, and easily soluble.

Benzoate of Alumina has a sharp bitter taste, is soluble in water, and deliquesces in the air.

Benzoate of Manganese forms thin prismatic crystals, which are colourless and transparent, soluble in 20 times their weight of water, soluble in alcohol, and constituted of 23.08 oxide, + 76.92 acid.

Benzoate of Zinc exists in needle-shaped crystals, which are soluble in water and alcohol.

Benzoate of Iron is an orange-yellow powder, insoluble in water. These characters apply to the compound formed by adding benzoate of ammonia to solution of peroxide of iron; but Tromsdorff states that oxide of iron is readily dissolved by an excess of benzoic acid, and forms yellowish crystals, which are soluble in water and in alcohol. (Ann. de Chim. xi. 316.)

Benzoate of Copper forms deep green crystals, which are soluble in water, but not in alcohol.

Benzoate of Lead.—Berzelius describes two benzoates of lead, the *neutral benzoate*, which is a light crystalline powder, sparingly soluble in water, and constituted of 49.66 acid, 46.49 base, and 3.85 water; and the *sub-benzoate*, formed by treating the first mentioned salt with solution of ammonia. The latter is insoluble, and consists of 26 acid, + 74 base. If then 1 atom of acid be united with 1 of base in the neutral salt, we have in the sub-benzoate 3 atoms of base to one of acid.

Process for obtaining Moroxylic Acid.—Vol. II. p. 167.

To obtain this acid in a separate state, the small grains, in which it occurs, were decomposed by acetate of lead, and to the insoluble precipitate, diluted sulphuric acid was added. From the liquid, fine needle-shaped crystals were obtained by evaporation, which had the taste of succinic acid; were not altered by exposure to air; dissolved readily in water and in alcohol; but did not, like succinic acid or its salts, precipitate metallic solutions. When heated in a retort, these crystals first yielded a little acid liquor, and then sublimed unaltered, adhering in colourless and transparent crystals to the top and neck of the retort.

Method of Rendering Oils drying:—Their Products, when exposed to Heat.—Vol. II. p. 171.

OILS may be rendered drying, by merely keeping them exposed to air; but the change is effected more rapidly by boiling them some time in an open iron pot, which gives them a higher colour and greater consistency. For some purposes, they are occasionally set on fire while boiling, and extinguished by covering the pot. This deprives them of their unctuousity more completely than any other method; and it is always practised with oil intended for printer's ink.

Fixed oils do not boil under 600° Fahr. An inflammable vapour arises from them under 500°, but this is condensable, and when rectified is highly volatile and inflammable. It does not appear that permanent gases are generated from oil under 600° Fahr.; but

at that temperature, or a little above it, water and olefant and carburetted hydrogen gases, are formed abundantly, with small proportions of acetic acid, carbonic acid, and carbonic oxide. Oil, transmitted through tubes moderately ignited, is wholly changed into these products and carbonaceous matter.

Properties and Composition of Spirit of Turpentine.—Vol. II.
p. 173.

ONE of the most useful and abundant of the essential oils is that of turpentine, called commonly *spirit of turpentine*. It is obtained by distilling turpentine and water, in due proportions, from a copper alembic. It is perfectly limpid and colourless, has a strong smell, a bitterish taste, boils at 316° , and is extremely inflammable. It is the solvent which is employed in making a variety of varnishes, but for the purposes of nicety, it requires to be rectified by a second distillation.

Dr. Ure analysed a specimen of sp. gr. 0.888, and found it to be composed of

Carbon, 14 atoms . . . 84	82.35
Hydrogen, 10 atoms . 10	9.80
Oxygen, 1 atom 8	7.85
	<hr/>
	102 100.

When purified by alcohol, it had the sp. gr. 0.878, and appeared to be compounded of carbon and hydrogen only, and to approach very nearly to the constitution of naphtha. (Phil. Trans. 1822.)

Properties and Composition of Camphor.—Vol. II. p. 173.

CAMPBOR is a white, semi-transparent, and highly inflammable solid, which, in some properties, resembles essential oils. It is obtained from the *laurus camphora*, in Japan, and other places in the East, by distilling the wood along with water. After being brought to Europe, it is refined by a second sublimation in vessels of glass, whose shape it takes. In this state, it has a crystalline fracture, is brittle, has an aromatic odour, and a hot acrid taste. Its specific gravity is 0.988.

Camphor melts at 288° Fahr., and boils at 400° . It is volatile, and evaporates spontaneously, and condenses, in the upper part of any glass vessel in which it is kept, in hexagonal plates or pyramids.

It is insoluble in water, but communicates its flavour to hot water when triturated along with it, especially if a little sugar be added. It is soluble to a considerable extent in alcohol, which takes

up 3-4ths of its weight. On adding water, the camphor is again precipitated. It is soluble also both in fixed and volatile oils, and in strong acetic acid.

Sulphuric acid was found by Mr. Hatchett to produce a complete decomposition of camphor, and to convert it into charcoal, a yellow oil, and a blackish-brown resin analogous to artificial tan. (Phil. Trans. 1805.)

The ultimate analysis of camphor has been performed by Dr. Ure, who represents its constitution as follows :

Carbon	10 atoms . . .	60	78.02
Oxygen	1 atom	8	10.40
Hydrogen	9 atoms	9	11.58
			<hr/>
			77 100.

Ultimate Analysis of Common Resin.—Vol. II. p. 174.

THERE is a remarkable want of agreement between different statements of the composition of the same kind of resin, arising, probably, from actual differences of the substance itself. Common resin afforded, in an analysis by Gay-Lussac and Thenard,

Carbon	75.944 . . . =	15 atoms . . .	90
Oxygen	13.337 . . . =	2 do.	16
Hydrogen	10.719 . . . =	13 do.	13
			<hr/>
			100. 119

But Dr. Thomson, (Ann. of Phil. xv.), analyzing it by peroxide of copper, obtained

Carbon	63.15 . . . =	10 atoms . . .	60
Oxygen	25.26 . . . =	3 do.	24
Hydrogen	11.59 . . . =	11 do.	11
			<hr/>
			100. 95

And resin which had been heated to 276°, and had lost a quantity of water, and probably of essential oil, afforded

Carbon	48.98 . . . =	4 atoms . . .	24
Oxygen	48.98 . . . =	3 do.	24
Hydrogen	2.04 . . . =	1 do.	1
			<hr/>
			100. 49

Dr. Ure states the following as the results of his analysis of resin :

Carbon	75.00	= 8 atoms	48
Oxygen	12.50	= 1 do.	8
Hydrogen	12.50	= 8 do.	8
	<hr/>		<hr/>
	100.		64

Statements, so much at variance with each other, sufficiently show that the ultimate analysis of resin still requires a fresh appeal to experiment.

In the analysis of copal, also, there is some disagreement, though less considerable, between the results of MM. Gay-Lussac and Thenard, and those of Dr. Ure: Copal consists, according to

	Carbon.	Oxygen.	Hydrogen.
Gay-Lussac and Thenard	76.811	10.606	12.583
Dr. Ure, from experiment	75.	12.50	12.50
Ditto, from theory	80.30	10.34	9.36

In the theoretical view, the carbon is increased, on account of the difficulty which was experienced in burning it completely by peroxide of copper. Thus modified, its constitution may be represented by 10 atoms of carbon + 1 of oxygen + 7 of hydrogen, and its equivalent by the number 75.

Properties of Amber.—Vol. II. p. 174.

AMBER is found in some places beneath the surface of the earth, and in others on the sea coast. It is hard, brittle, nearly transparent, sometimes almost colourless, but generally of a peculiar yellow colour, which has been called *amber yellow*. Its specific gravity is 1.065; it is insoluble in water; but alcohol by long digestion takes up about 1-8th of the amber, and forms a solution which is rendered milky by adding water. The residue is not soluble in alcohol. Amber is soluble in boiling solution of potassa, and after a length of time in alkaline carbonates.

Weak acids do not act on amber. Sulphuric acid converts it into a black resinous mass. Nitric acid dissolves it, but no oxalic acid is formed. After being melted, it becomes soluble in linseed oil, and forms *amber varnish*.

Account of Several Succinates.—Vol. II. p. 175.

Succinate of Potassa crystallizes in three sided prisms. It is bitter, very soluble, and deliquescent.

Succinate of Soda forms beautiful transparent crystals, which have a bitter taste, are not deliquescent, and are less soluble than the foregoing salt.

Succinate of Ammonia does not readily crystallize, but may be obtained in small needles, which have a sharp bitter taste and may be sublimed without decomposition. Its solution precipitates per-

oxide of iron of a deep red colour. It also throws down baryta and mercury; and with the oxides of lead, copper, and perhaps some other oxides, forms white precipitates, which are dissolved on adding a large quantity of water. It is much employed as a test of iron.

Succinate of Baryta is an almost insoluble compound.

Succinate of Strontia forms crystals as fine as sand, which are considerably more soluble than the last mentioned salt, and their solution precipitates barytic salts.

Succinate of Magnesia is deliquescent and not crystallizable.

Succinate of Alumina crystallizes in prisms.

Succinate of Manganese forms rose-red crystals, insoluble in alcohol, and requiring ten times their weight of water for solution.

Succinate of Iron, formed by adding succinate of ammonia to the solution of any salt containing peroxide of iron, is insoluble in water. In 100 parts, it contains 38.5 peroxide. To estimate the quantity of base, Dr. Thomson advises to multiply the weight of the precipitate, dried as perfectly as possible without decomposing it, by 0.444, which gives the peroxide of iron. To estimate the acid, multiply by 0.555. (Ann. of Phil. N. S. ii. 141.)

Succinate of Lead, formed by double decomposition, consists, according to Berzelius, of 30.9 acid + 69.1 protoxide, or of 100 acid + 222 base. By digesting this compound in liquid ammonia, he obtained a sub-succinate, consisting of 100 acid + 666 base. In the first salt we have an atom of each element; in the second, 1 atom of acid + 3 atoms of base.

Spontaneous Changes occurring in Starch, when mixed with Water.—Vol. II. p. 178.

STARCH, by being long kept in a state of mixture with water, either in vacuo or with the access of air, undergoes a series of changes, which have been attentively investigated by Vogel and Saussure. Vogel found that starch and water, kept during four days in ebullition, became much more fluid, and that a liquid drained from it when placed on a linen cloth, which was mucilaginous and bitter, but not in the least degree saccharine. The residuum was insoluble in water and resembled horn. Saussure left a paste formed of starch and 12 times its weight of water exposed to the air with a wide surface during two years. It had then become a gray liquid, covered with mould, free from smell, and having no action on vegetable blue colours. The starch had lost nearly one-fourth of its weight, and the remainder was converted into the following substances:

1. Sugar, amounting to one-half of the starch.
2. Gum, or rather a substance resembling it, and analogous to what is obtained by roasting starch.
3. Amyline.
4. Starchy lignin.
5. Lignin mixed with charcoal.

Amyline (called *amydine* by Saussure) is intermediate between gum and starch. It is soluble in boiling water, and the solution yields by evaporation a pale semitransparent brittle substance, insoluble in alcohol, but soluble in ten times its weight of cold water, and to any amount in water at 144°. The solution is coagulated into a white paste by sub-acetate of lead. When treated with iodine, it assumes a blue colour. It is precipitated by barytic water, but not by fixed alkalies, by lime-water, nor by infusion of galls.

Starchy Lignin.—When the residue of the spontaneous decomposition of starch has been washed successively with cold and hot water, with alcohol, and with diluted sulphuric acid, an alkaline ley, containing 1-12th its weight of potassa, still takes up a further portion. From this solution, diluted sulphuric acid precipitates a light brown combustible substance having the appearance of jet. It gives a blue colour to the aqueous solution of iodine, a property which, together with its solubility in a weak alkaline liquor, distinguishes it from common lignin. It is not impossible, however, that the effect of iodine may depend on the presence of a small quantity of starch.

Process for forming a fine Prussian Blue, by the intervention of Starch.—Vol. II. p. 179.

WHEN four parts of starch, and one of finely powdered prussian blue, are intimately mixed, and then boiled in a considerable quantity of water, a liquid is obtained, which, if heated with a solution of sulphate of iron, mixed with an equal volume of solution of chlorine, forms a very fine prussian blue. The starch by this combination appears to be changed in its nature, and converted into an imperfect kind of gum. (Ann. of Phil. xiii. 69.)

Ultimate Analysis of Starch.—Vol. II. p. 179.

STARCH from wheat has been analyzed by Gay-Lussac and Thenard, and that from potatoes by Berzelius, and the near coincidence of their results, obtained by different methods, is a strong presumption in favour of their accuracy, as well as of the uniformity of this substance, from whatsoever source it may be obtained.

Dr. Ure found starch to consist of 38.55 carbon, + 6.13 hydrogen, + 55.32 oxygen; but as he acknowledges that the starch submitted to his experiments had not been chemically dried, it is probable that they indicate too little carbon and too much oxygen.

The equivalent of starch, if deduced from its ultimate analysis, would approach very closely to that of sugar. It is probable, indeed, that in this, as well as in other instances of vegetable compounds, the difference consists merely in the manner in which the elementary atoms are arranged; a view of the subject, with which

the conversion of starch into sugar, by processes not attended with the evolution of any gaseous products, is perfectly consistent. Berzelius investigated the equivalent of starch, by examining the composition of the insoluble *amylate of lead*, formed by mixing a boiling solution of potato starch with one of sub-nitrate of lead. (Ann. of Phil. v. 272.) This he found to consist of 72 parts of starch + 28 of oxide of lead; and, reasoning from its composition, he infers that starch must be constituted, either of 6 atoms of oxygen + 7 of carbon + 13 of hydrogen, or of 18 atoms of oxygen + 21 of carbon + 39 of hydrogen. In this case, the same agreement does not exist between the number deducible from ultimate analysis and from a compound of the entire substance with oxide of lead, as in the instance of sugar; for the equivalent, most consistent with the first supposition, would be not less than 103; whereas that for sugar is only 81. In this, as in various other cases, where the constitution of organic substances is concerned, it is better to wait for the further progress of science, than to rest satisfied with equivalent numbers, which are not supported by the concurrence of different methods of investigation.

Varieties of Starch.—Vol. II. p. 179.

Indian Arrow Root is obtained from the roots of the *Maranta Arundinacea*, L, a plant cultivated in the West Indies. The roots, first well washed, are beaten in large and deep wooden mortars to a pulp. This is thrown into a tub full of clean water, where it is well worked with the hands, and the fibrous parts are wrung out and thrown away. The milky liquor is passed through a hair sieve and allowed to settle, and the clear liquor drained off. The powder at the bottom of the vessel is again repeatedly washed, and then dried in the sun.

Sago is prepared from the pith of a palm-tree, (*Cycas circinalis*, L.), which grows spontaneously in the East Indies. The pith is scooped out, diluted with water, and passed through a straining bag, which detains only the fibrous matter. The sago is allowed to settle, and when partly dry is granulated by forcing it through apertures of the proper size. Its colour is occasioned by the heat used in drying.

Cassava and Tapioca are prepared from the roots of the *Jatropha Munihtat*, a plant common in South America. By pressure, a juice of poisonous quality flows out; yet the sediment from it, called, when well washed and dried, *Cassava*, is perfectly innocent; and is made into a nutritious bread. Tapioca is the same substance, under a different form, which it assumes in drying.

Salop, or *Saloop*, is the farina obtained from several species of *Orchis*, especially the *O. Masculula*. It is extracted by processes similar to those which have already been described.

Relative proportion of Gluten in Wheat of different Countries.—
Vol. II. p. 180.

SIR H. DAVY discovered a larger proportion of gluten in North American wheat, than in the wheat of England; and in general found it more abundant in the wheat of warm climates. (El. of Agric. Chem. p. 141.) It is in consequence of its abounding in this principle, that the wheat of the South of Europe is peculiarly fitted for making macaroni and other glutinous preparations. The grain containing most gluten is distinguished by its hardness and great specific gravity. Of particular grains, Sir H. Davy ascertained the composition of the following. He found

	Starch.	Gluten.
100 parts of good full-grained wheat, } sown in Autumn to afford }	77	19
100 parts of wheat sown in Spring	70	24
100 parts of Barbary wheat	74	23
100 parts of Sicilian wheat	75	21
100 parts of full and fair Norfolk barley .	79	6
100 parts of Suffolk rye	6	5

Proximate Analysis of Gluten into Gliadine and Zimome.—
Vol. II. p. 180

FROM the experiments of M. Taddei, an Italian Chemist, it appears that the gluten of wheat may be decomposed into two principles, one of which he has distinguished by the name of *Gliadine*, (from $\gamma\lambda\alpha$, gluten), the other, of *Zimome* (from $\zeta\upsilon\mu\eta$, a ferment.) To separate them, fresh gluten must be kneaded with repeated portions of alcohol, as long as that fluid becomes milky by dilution with water. The alcohol dissolves the gliadine and leaves the zimome.

By evaporating the alcoholic solution, gliadine is obtained, forming a brittle, straw-yellow, slightly transparent substance, with a weak smell resembling that of the honeycomb, and when gently heated, emitting an odour similar to that of boiled apples. In the mouth, it becomes adhesive, and has a sweetish and balsamic taste. It is pretty soluble in boiling alcohol, but the greater part precipitates as the alcohol cools. It softens, but does not dissolve in cold water. Its alcoholic solution becomes milky on adding water, and is precipitated, in white flocks, by alkaline carbonates. Dry gliadine dissolves in caustic alkalies and acids. It swells on burning coals, and then contracts like animal matter. It burns with a bright flame, and leaves a portion of charcoal which is difficult to be incinerated.

Zimome is obtained pure by boiling gluten in alcohol, or by digesting it in that fluid till it ceases to give out gliadine. There

remains a shapeless mass, which is hard, tough, destitute of cohesion, and of an ash-white colour. After being washed with water, it recovers part of its viscosity; and becomes brown when left in contact with air. It is specifically heavier than water. It does not ferment like gluten, but putrefies, exhaling a fetid urinous odour. At a boiling temperature, it is soluble in vinegar and in the mineral acids. It combines with potassa, and forms a kind of soap. Lime-water, and solutions of alkaline carbonates harden it, and give it a new appearance. It inflames when thrown on red-hot coals, and emits an odour similar to that of burning hair or hoofs. (Ann. of Phil. xv. 390, xvi. 88.)

M. Taddei has since discovered that powdered guaiacum is a test of the presence of zimome. When well kneaded with good wheat flour and a little water, the guaiacum becomes of a very fine blue colour. Starch does not evolve this colour, and bad flour in only a very small degree. But when guaiacum is worked up with gluten, and, still better with pure zimome, the colour instantly appears, and is a most superb blue. Guaiacum, however, does not become at all coloured by zimome, unless the contact of oxygen be allowed. The powder of guaiacum is, therefore, a re-agent, capable of detecting the injurious alteration which flour sometimes undergoes by the spontaneous destruction of its gluten, and also of ascertaining in a general way the proportion of that principle. (Quarterly Journal, viii. 377.)

Varnish for Iron or Steel Instruments, formed of Caoutchouc.—
Vol. II. p. 180.

CAOUTCHOUC fuses at a heat, which is not much below that required for melting lead. In this state, Mr. A. Aikin finds, that it may be brushed over iron or steel instruments, and that it forms a transparent coating, which effectually preserves them from rust. The best method of melting it for this purpose is in a kind of copper flask, containing a horizontal stirrer or agitator, which is kept in motion by a handle rising above the flask. (Gill's Technical Repository, i. 54.)

Ultimate Analysis of Caoutchouc.—Vol. II. p. 181.

CAOUTCHOUC, from the analysis of Dr. Ure, (Phil. Trans. 1822), appears to consist of

Carbon	90.00	3 atoms	18
Oxygen	0.88	0 atom	
Hydrogen	9.12	2 atoms	2
	<hr/>		<hr/>
	100.		20

The oxygen found by analysis is in too small a quantity to be considered as essential; and we may therefore consider caoutchouc as a sesqui-carburetted hydrogen.

Action of Caustic Potassa and Sulphuric Acid on woody Fibre.—
Vol. II. p. 181.

If equal weights of caustic potassa and sawings of wood are heated in a silver or iron crucible, stirring constantly, the wood softens and dissolves completely. Water, poured upon the product when cold, dissolves the whole of it, and the addition of an acid, in such quantity as barely to neutralize the alkali, precipitates a substance analogous to ulmin. (Ann. of Phil. xvi. 92.)

When dried sawings of hornbeam are mixed and agitated with sulphuric acid, and water is then added, a black powder falls; and the liquid, after being saturated with carbonate of lime and filtered, yields, by evaporation, a gum in several respect analogous to gum arabic. (Braconnot, Ann. of Phil. xvi. 90.)

Atomic Constitution of Lignin.—Vol. II. p. 182.

THE atomic constitution of lignin, which agrees most nearly with the results of its ultimate analysis, is the following:

Carbon	7 atoms . . .	42	53.86
Oxygen	4 ditto . . .	32	41.02
Hydrogen	4 ditto . . .	4	5.12
		<hr/>	
		78	100.

If deprived, therefore, of 1 atom of water and 3 atoms of carbon, the other elements of lignin should be convertible into acetic acid.

Composition of the Indigo of Commerce.—Vol. II. p. 183.

THE indigo of commerce is never pure, but contains variable proportions of foreign matter, amounting generally to above half its weight. Bergman, in 100 parts, found

Pure Indigo	47
Gum	12
Resins	6
Earths	22
Oxide of iron	13
<hr/>	
100	

The earthy matter consisted of baryta and lime in equal weights, with silica in the proportion of 1-10th of the whole earths.

Chevreul, by acting in succession upon Guatimala indigo, first with water, then with alcohol, and finally with muriatic acid, found its composition to be still more complicated. The yellow solution, obtained by hot water, let fall a greenish matter becoming blue on exposure to the air, and thus acquiring the properties of indigo. After this had ceased, green flocks formed and subsided, to which Chevreul gave the name of *green matter*. It is soluble in alkalis, and in alcohol, but is not convertible into indigo by exposure to air. From the indigo on which water had ceased to act, alcohol dissolved a further portion, the greater part of which was the green matter, already described, with a *red matter*, differing only in colour, but possessing similar chemical characters. Lastly, muriatic acid dissolved more of the red matter, together with lime, alumina, and oxide of iron; and indigo, amounting to 45 parts from 100, and free from every thing but a little silica, remained.

Action of Dilute Nitric Acid on Indigo.—Vol. II. p. 184.

WHEN the action of nitric acid on indigo is moderated by adding an equal bulk of water, and the mixture, after being digested for some days, is evaporated to dryness; the residuum is soluble in water, and contains a small proportion of oxalic acid, with a considerable quantity of artificial tan. Benzoic acid may also be obtained from the dry mass by sublimation. It appears then that by the action of nitric acid on indigo, there are generated oxalic and benzoic acids, tan, and the bitter principle. Muriatic, phosphoric, acetic, tartaric, and probably other acids, act on indigo only when it is fresh precipitated, and then they dissolve it and afford a blue liquid.

New Researches on Indigo.—Vol. II. p. 184.

AN interesting paper, containing "Experiments and Observations on Indigo, and on certain substances which are produced from it by means of Sulphuric Acid," by Mr. Walter Crum of Glasgow, appeared in the *Annals of Philosophy*, N. S. v. 81. Of this paper, I shall give only a brief notice, referring, to the memoir itself, those who are concerned in the practical use of Indigo.

To obtain indigo of sufficient purity for experiment, the yellow solution of de-oxidized indigo by lime, which forms the dyer's blue vat, may be agitated in contact with air, which will revive the indigo, and precipitate it purified to a certain degree. The precipitate may be digested in dilute muriatic acid, which will remove a little iron and carbonate of lime. It is then to be washed with distilled water, and dried.

Indigo may be purified more completely by sublimation. About ten grains of purified indigo, in lumps of about 1 grain, may be placed in a shallow metallic capsule of about 3 inches diameter, covered with a similar capsule, the concave sides of both being placed inwards, and at a distance not exceeding three-eighths of an inch in the middle. Mr. Crum used two platinum crucible covers, but similarly shaped vessels of other metals would probably answer equally well. The lower capsule is to be heated by a spirit lamp; and when a hissing noise, which at first attends the process, has nearly ceased, the lamp is to be withdrawn, and the apparatus allowed to cool. On removing the cover, the sublimed indigo is found planted on its inner surface, forming long flat needles, in quantity equal to 18 or 20 per cent. of the original weight, and of a brilliant and intense copper colour. The colour, however, varies with the circumstances under which the crystals are observed. The specific gravity of the sublimate is 1.3.

Sublimed indigo is fusible and volatile at a heat of about 550° Fahrenheit, leaving no residue when heated in open vessels. Its vapour is transparent and of a beautiful violet colour, differing from that of iodine by a shade of red. The melting point of indigo, that at which it sublimes, and that at which it is decomposed, appear to be remarkably near to each other. Boiling oil of turpentine dissolves enough of purified indigo to acquire the same fine violet colour as its vapour, but deposits it again on cooling.

By the ignition of sublimed indigo with peroxide of copper in green glass tubes, its analysis gave

Carbon	73.22
Azote	11.26
Oxygen	12.60
Hydrogen	2.92
	<hr/>
	100.00

These numbers correspond very nearly to

Carbon . . 16 atoms =	96 . . or . .	73.84
Azote . . 1 ditto =	14	10.77
Oxygen . . 2 ditto =	16	12.31
Hydrogen . 4 ditto =	4	3.08

Equivalent number . .	130	100.
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Mr. Crum objects properly to the application of the term *indigogene*, applied by Brugnatelli to sublimed indigo, and denies the power, which has been ascribed to the sublimate, of amalgamating with mercury.

When indigo is acted upon by strong sulphuric acid, it is not merely dissolved, but if heat be applied is, in less than 24 hours, changed into a new substance. No sulphurous acid is evolved, nor is there any absorption of oxygen from the air, or any separation of carbon. From the solution, diluted with water, potassa and its

X (8.)

sulphate throw down a deep blue precipitate, which is soluble in water, and capable of passing through a filter, but is not soluble in saturated solutions of salts with base of potassa. The precipitate was purified, therefore, by washing, first with a solution of acetate of potassa, and then with alcohol. The edulcorated precipitate has, when wet, a colour of so deep a blue as to appear black; when dry, it is copper-red. It attracts water rapidly from the air; is soluble to a considerable extent in boiling water; but requires 140 parts of cold water for solution. Water containing only $\frac{1}{1000}$ of its weight of the precipitate is still distinctly blue. The cold solution, diluted with 20 parts of water, is precipitated by salts of potassa, soda, lime, baryta, strontia, lead, and mercury, and the precipitates are not redissolved by acids. A variety of other salts that were tried were found not to produce the same effect.

From the analysis of this precipitate, Mr. Crum considers it to be a compound of sulphate of potassa with a peculiar substance, to which he gives the name of *Cerulin*, and to the precipitate, that of *Ceruleo-sulphate of Potassa*. In its property of forming insoluble compounds with neutral salts, cerulin is analogous to *tan*, which, according to Sir H. Davy, has similar effects on several of the salts of potassa. From its ultimate analysis, cerulin appeared to consist of 1 atom of indigo + 4 atoms of water.

If the action of the sulphuric acid on indigo be suspended before it has gone far enough to produce *cerulin*, which, at the ordinary heat of summer, may be three hours, at 100 Fahr., twenty minutes, a new substance altogether different from cerulin is produced, possessing rather singular properties. One part of purified indigo may be agitated with ten of sulphuric acid in a stoppered vial, till it assumes a bottle-green colour, then poured into a large quantity of distilled water, agitated, and thrown on a filter. On continuing to wash the substance, on the filter, with more water, the first washings are colourless, and must be thrown away; but afterwards a blue liquid passes through, which contains the new substance. Muriate of potassa precipitates it of a beautiful reddish-purple colour, exactly similar to that of the vapour of indigo. The precipitate is to be thrown on a filter, and washed with distilled water, till the liquid which passes through forms a red precipitate with nitrate of silver. From the property, possessed by this substance, of becoming purple-coloured on the addition of certain salts, Mr. Crum terms it *phenecin*.

Phenecin is soluble both in water and alcohol, and the solution in both cases is blue. All saline substances without exception precipitate it again of its original colour, but some require to be added in much larger proportion than others. Acids do not prevent its precipitation. It dissolves in liquid ammonia, but fixed alkalies destroy it, though not very easily. Sulphuric acid dissolves it, and in due time converts it wholly into cerulin.

From its ultimate analysis, Mr. Crum is disposed to consider phenecin as constituted of 1 indigo + 2 water. It would be re-

markable, however, if the continued action of sulphuric acid should be found to add two atoms of water, which must be the case, if the constitution of this substance and of cerulin be correctly assigned, the latter being 1 indigo + 4 water. This is contrary to the usual agency of sulphuric acid, which, when it acts on vegetable substances, generally abstracts the water which they already contain.

Tromsdorff's Process for obtaining Tannin.—Vol. II. p. 186.

THE following process, practised by Tromsdorff, is described by Dr. Thomson, (*System of Chemistry*, iv. 212), as yielding tan of greater purity than any other method. Three parts of bruised galls were digested with 40 parts of water for three days, at the temperature of 66° Fahr., the mixture being frequently stirred. The whole was now placed on a linen strainer, the liquid set apart, and the residuum treated as before with 40 parts of water. Four different infusions were thus made, all of which were gently evaporated together to one-fourth their bulk in a porcelain basin. The liquid, being drained through a thick linen cloth, was further evaporated to the consistence of a jelly, and placed upon a flat porcelain dish near a stove till it became dry. The dry mass was digested with thrice its weight of *pure* alcohol; and this digestion was repeated three times, till the last portion of alcohol was found to be free from *gallic acid*; and to remove this acid effectually, the dry mass was digested, twice in succession, with alcohol, containing ten per cent. of water. The tan, however, was still considered as contaminated with extractive and mucilaginous matter. To get rid of these, the whole was dissolved in distilled water, and again evaporated to dryness. These solutions and evaporations were repeated several times, with the view of rendering the extract insoluble; but nothing insoluble was thus separated. The last solution, being left some time in a warm place, contracted a mouldy scum, which was removed. The liquid beneath it, being evaporated to dryness, left tan of considerable purity, but still containing sulphate of lime. To separate this, the tan was dissolved in water, and carbonate of potassa added as long as any precipitate fell. The liquid was then filtered and mixed with acetate of lead, which threw down a compound of oxide of lead and tan. This powder was washed and dried, and being diffused in water, a current of sulphuretted hydrogen was transmitted through it. The lead was thus thrown down in union with sulphur, while the tan dissolved in the water. The liquid, after being boiled, filtered, and evaporated to dryness, gave tan in a state of as great purity as can be obtained from nut-galls.

Compound of Tannin and Gelatin, or Tanno-gelatin.—
Vol. II. p. 187.

TANNO-GELATIN is soluble in liquid ammonia, and forms a dark brown solution, which, when spread with a brush, leaves a film insoluble in water, oil, or alcohol. The solution, by long-keeping, changes its nature, and when filtered and evaporated, yields a brittle shining black substance, soluble in water and alcohol, but not in ether. From the extreme facility with which it yields ammonia on being heated, it is probably a compound of that alkali with tanno-gelatin. (Faraday, in Quarterly Journ. vi. 157.)

Tanno-gelatin, boiled with solution of bi-chloride of mercury, becomes of a fawn colour, is more soft and pliable in the warm fluid, and does not, when exposed to the air, become so hard and brittle as unaltered tanno-gelatin. Its colour is also much lighter, and of a uniform brown tint. On analysis, it yields corrosive sublimate. (Ibid.)

Ultimate Analysis of Tannin.—Vol. II. p. 188.

BERZELIUS analyzed tan by the combustion of perfectly dry tannate of lead with peroxide of copper. The tannate of lead had been precipitated from infusion of nut-galls. He found tan to consist of

By Experiment.				By Theory.			
Carbon	. . 50.55	. . 6 atoms	. . 36	. . 50.70			
Oxygen	. . 45.	. . 4 ditto	. . 32	. . 45.07			
Hydrogen	. . 4.45	. . 3 ditto	. . 3	. . 4.23			
	<hr/>			<hr/>			
	100.			71	100.		

On the supposition that tannate of lead is composed of an atom of each of its elements, a much higher number would be indicated for tan, viz. 215.4; for 52 : 100 :: 112 : 215.4. The equivalent thus deduced is at variance, therefore, with that derived from ultimate analysis, unless we suppose that the tannate of lead consists of 1 atom of base, united with 3 atoms of tan. This would reduce the atom of tan to 71.8, which accords as nearly as can be expected with the foregoing number. By comparing the composition of gallic acid, as stated at page 136 with that of tan, it will appear that the only difference between them is, that the former contains an atom less of oxygen, which would scarcely have been expected in a substance possessing more decidedly acid properties than belong to tan.

Ultimate Analysis of Yellow Wax.—Vol. II. p. 191.

ACCORDING to Dr. Ure, yellow wax consists of

Carbon	80.69
Oxygen	7.94
Hydrogen	11.37

100.

The atomic constitution, most consistent with this result, is,

Carbon	13 atoms	78	80.41
Oxygen	1 atom	8	8.26
Hydrogen	11 atoms	11	11.33

97

100.

But it is not improbable, as Dr Ure has remarked, that an atom more of hydrogen may exist in wax than has been discovered by analysis, and that it may consist of 12 atoms of olefiant gas + 1 atom of carbonic oxide.

General Properties of Native Vegetable Alkalies.—
Vol. II. p. 193.

THE forcēs, which produce in living vegetables so many acids, appear also to be capable of giving rise to a variety of alkaline substances, several of which have been discovered and identified during the few last years. So far as is yet known, the processes, by which they are obtained, effect nothing more, than their separation from the vegetables in which they exist ready formed. These vegetables are for the most part distinguished by very powerful effects on the animal system, produced, it should appear, by an alkaline ingredient peculiar to each species; and it is probable that the active principles, thus detached, may hereafter become important instruments in the hands of the physician. It is chiefly from their habitudes of chemical combination, that these new substances are classed among alkalies, which they resemble in the power of neutralizing acids, and of affording with them compounds analogous to the salts, which result from the union of acids with the alkaline substances that have been long known. They have all, however, weaker affinities for acids, than belong to alkalies of the latter class; and are destructible, both when separate and in combination, at low degrees of heat. At first they were distinguished by names ending in *ine*, as morphine, strychnine, &c.; but, for the sake of conformity to the nomenclature of other alkalies, their names have since received a different termination.

Besides these alkalies of feeble energy, it has been discovered by Dr. Peschier, of Geneva, that potassa, which had been long

extracted from the ashes of plants, exists ready formed in their juices, and may be obtained by agitating pure magnesia with the liquor, obtained by pressure or decoction of any part of the vegetable, except its fruit. In most plants, the potassa is united with oxalic or tartaric acid, which form insoluble compounds with magnesia; but in borage, the potassa is combined with nitric acid, which magnesia has not the power of detaching from that alkali. (Ann. of Phil. xii. 336.)

Dr. Thomson's Process for obtaining Morphia.—Vol. II. p. 194.

DR. THOMSON finds that morphia may easily be procured, in a state of purity, by pouring liquid ammonia into a strong infusion of opium; separating by a filter the brownish-white precipitate which is formed; evaporating the infusion to about 1-6th of its bulk, and adding more ammonia, which throws down a fresh precipitate. These precipitates are impure morphia. To purify it, pour a little alcohol upon it, and let the alcohol, which chiefly takes up the colouring matter, pass through the filter. Dissolve the residuum in acetic acid, and mix the solution, which will have a deep brown colour, with a sufficient quantity of ivory black. After being occasionally agitated during 24 hours, and thrown upon a filter, a colourless liquid passes through, from which ammonia now precipitates pure morphia in the state of a white powder. If this be dissolved in alcohol, and the solution slowly evaporated, morphia is obtained in pretty regular crystals, which are four-sided rectangular prisms. (Ann. of Phil. xv. 470.) Pure morphia is perfectly white, has a pearly lustre, is destitute of smell, but has an intensely bitter taste.

Account of Several newly-discovered Native Vegetable Alkalies.
Vol. II. p. 195.

STRYCHNIA.—This substance was detected by Pelletier and Caventou, in 1818, in the fruit of the *Strychnos Nux Vomica*, and *Strychnos Ignatia*. The bean was rasped down as small as possible, and then exposed to the action of heated nitric ether. The residue, thus deprived of a quantity of fatty matter, was digested in alcohol, added in successive portions as long as it continued to dissolve any thing. The alcoholic solutions were evaporated, and the residue dissolved in water. From the watery solution, liquid potassa threw down a white crystalline precipitate, which was *strychnia*. It was purified by washing it with cold water, dissolving in alcohol, and crystallizing it. Strychnia was separated also from the bean of the *strychnos ignatia* by the use of magnesia, in the same manner as Robiquet had obtained morphia from infusion of opium.

Strychnia crystallizes in very small four-sided prisms, terminated by four-sided low pyramids. It is white, intensely bitter, destitute of smell, neither fusible nor volatile at moderate temperatures, very sparingly soluble in cold water, and even in hot water, of which it requires for solution 2500 times its weight. But though it is not soluble in less than from 6 to 7000 parts of cold water, the solution may be diluted with 100 times its volume of water without losing its taste. It is one of the most virulent and active poisons yet discovered. Half a grain, blown into the throat of a rabbit, brought on locked jaw in two minutes, and in five minutes proved fatal.

Strychnia acts as a base to acids, and forms a distinct set of salts, which are described in the *Annals of Philosophy*, xvi. 30, and in the *Ann. de Chim. et Phys.* x. 142.

BRUCIA.—This substance was also extracted by Pelletier and Caventou from the bark of the *Brucia Antidysenterica*. The bark was first digested in sulphuric ether, and then in alcohol; the alcoholic solution evaporated; and the dry residuum dissolved in water. This solution was saturated with oxalic acid, and evaporated to dryness. Alcohol, digested on the residue, took up the colouring matter, and left the oxalate of brucia pure. This salt was decomposed both by lime or magnesia, which formed insoluble salts with the oxalic acid, and left the brucia soluble in water, of which it requires 500 parts at 212° , and 850 at common temperatures.

Brucia crystallizes in oblique prisms, with parallelograms for their bases. It has a bitter taste, but less so than strychnia. This taste is more acrid, however, and continues for a longer time. It melts when heated to a little above 212° , and congeals on cooling into a mass resembling wax. It dissolves in sulphuric and other acids, and neutralizes them, affording a distinct class of neutral salts. (See *Ann. of Phil.* xv. 311, or *Ann. de Chim. et de Phys.* xii. 113.)

DELPHIA.—This alkaline principle was detected in 1819, by MM. Lassaigne and Feneulle, in the seeds of the *Delphinium Staphysagria*, or *Stavesacre*, in which it exists united with malic acid. The seeds were well cleaned and reduced to a pulp; then boiled with water; and the fluid part separated by a filter. The liquid was boiled for some minutes with a quantity of pure magnesia. The solid part of this mixture was then separated by a filter, and digested in boiling alcohol. From this solution, by evaporation at a gentle heat, delphia was obtained in a state of tolerable purity.

Delphia is a white powder, having a crystalline texture while moist, but becoming opaque by exposure to air. Its taste is intensely bitter and acrid; it is destitute of smell. It melts when heated, and resembles liquid wax, and on cooling becomes hard and brittle like resin. Cold water does not dissolve a sensible portion, though it acquires an acrid taste. Alcohol and sulphuric ether dissolve it readily, and the former solution gives a green

colour to sirup of violets, and restores the blue colour of litmus, which has been reddened by vinegar.

Delphia unites with acids, and forms neutral salts, which are all very soluble in water, and have a very acrid and bitter taste. (Ann. of Phil. xvi., or Ann. de Chim. et de Phys. xii)

PICROTOXIA.—This name has been given by Boullay to the acrid narcotic principle residing in the *cocculus indicus*, the fruit or berry of the *Menispermum Cocculus*. From a strong infusion of the seeds, ammonia, added in excess, precipitated a white granular crystalline powder. This powder, after being washed with cold water partially dissolved in alcohol without colouring it; and, on the spontaneous evaporation of the alcohol, was separated in beautiful silky needles. Similar crystals were obtained by adding pure magnesia to an alcoholic infusion of the seeds. A grayish deposit was formed, which, after being lixiviated with boiling alcohol, afforded crystals as before.

ATROPIA.—In the analysis of the leaves of the *Atropa Belladonna*, M. Brandes found that pure alkalies precipitated, from the decoction of the leaves in water, a substance which had alkaline properties like morphia. He boiled two pounds of the dried leaves in repeated quantities of water, mixed the decoctions, and added a little sulphuric acid, which rendered the solution thinner, and enabled it more readily to pass the filter. The decoction was then supersaturated with potassa, by which he obtained a precipitate, that, after being washed with pure water and dried, weighed 89 grains. It consisted of small crystals, from which, by repeated solution in acids and precipitation by alkalies, the new alkaline substance, *atropia*, was obtained in a state of purity.

The external appearance of *atropia* varies considerably according to the mode of its preparation, being either granular, or flaky, or gelatinous, like precipitated alumina. When perfectly pure, it is snow-white, otherwise it has a yellow tinge. It is quite tasteless.

Cold water has scarcely any effect upon dried *atropia*, but dissolves a minute portion when recently precipitated, and boiling water dissolves still more. It is very sparingly soluble in cold alcohol, but boiling alcohol dissolves it readily, though less abundantly than morphia, and, on cooling, the greater part is again deposited. Ether and oil of turpentine had little effect upon it even at a boiling heat. Hot oil of almonds dissolved a much larger quantity of it, and seemed to become less fluid.

Atropia forms salts with acids, the greater number of which are readily soluble in water; but they cannot be obtained without such an excess of acid as affects the colour tests. There cannot, however, be a doubt that *atropia* serves as a base, and is a true alkali; and there are strong reasons for believing, that its combinations with sulphuric and muriatic acids are *bi-sulphates* and *bi-muriates*. At present it would be premature to assign the equivalent of this alkali.

Atropia produces violent effects on the animal system, and M.

Brades was obliged to refrain from its investigation by the unpleasant symptoms which it occasioned. Even the vapour of its different salts produced giddiness, and dilatation of the pupils of the eyes. (Ann. of Phil. N. S. i. 263.)

VERATRIA.—In July 1819, MM. Pelletier and Caventou discovered a new vegetable alkali, united with an excess of gallic acid, in the seeds of the *Veratrum Sabadilla*, the root of *Veratrum album*, and in that of the *Colchicum autumnale*. After acting upon the seeds with ether, the residue was digested in heated alcohol. By its action a coloured tincture was obtained, which, on cooling, deposited white flakes analogous to wax. The liquid portion, evaporated to dryness, was soluble in cold water, except a small quantity of fatty matter. The watery solution, gently evaporated, deposited an orange-coloured precipitate, and, when this ceased to appear, acetate of lead was poured into the residuary liquor, which had still a deep colour. Immediately a very abundant yellow precipitate fell, which was separated by a filter, and the liquid, which passed through, was almost colourless. It contained, beside other substances, acetate of lead, from which the lead was precipitated by sulphuretted hydrogen. To the liquid, filtered and concentrated by evaporation, magnesia was added, and it was again filtered. The clear liquid contained acetate of magnesia and colouring matter; the magnesian precipitate was washed with several portions of alcohol; and the alcoholic solution gave, on evaporation, a powder which was excessively acrid, and had distinctly alkaline characters.

Veratria is white and pulverulent, and destitute of smell; but when inhaled into the nostrils, it produces violent and dangerous sneezing, even when the quantity is too small to be weighed. Its taste is acrid in the highest degree, but without any bitterness. In very minute quantity, it produces dreadful sickness and vomiting, and in the quantity of a few grains would doubtless prove fatal.

It is not more soluble in cold water than morphia or strychnia. Boiling water takes up $\frac{1}{1000}$ th part of its weight, and acquires an acrid taste. It is extremely soluble in alcohol; and ether also dissolves it, but in less quantity.

Veratria fuses at the temperature of 122° , and has then the appearance of melted wax; on cooling, it becomes semi-transparent and amber-coloured. It restores to blue the colour of reddened litmus paper, and saturates acids, forming with them salts which are not crystallizable, and the elements of which are so weakly combined as to be separated by the mere action of water. Nitric acid, if heated and concentrated, alters the arrangement of its elements, and decomposes it, but does not produce a red colour, as with morphia, strychnia, and brucia. In this respect, and in affording acid salts, it approaches to picrotoxia. (Ann. de Chim. et de Phys. xiv. 69.)

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HYOSCYAMA.—In the *Annals of Philosophy*, xvi. 69, is a brief notice of another alkali extracted by M. Brandes from *Hyoscyamus Niger*, or henbane. It is not easily altered by a high temperature, even when heated to redness with charcoal. It crystallizes in long prisms, and, when saturated with sulphuric acid, or still better with nitric acid, affords very characteristic salts.

CINCHONIA.—This substance was first extracted by Dr. Gomes of Lisbon, from Peruvian bark (*Cinchona Condaminea*); but the process which he followed, leaving it united with some other matter, it was at first mistaken for a resin. MM. Pelletier and Caventou were the first who suspected that cinchona contained a salifiable base analogous to morphia and the other vegetable alkalies, and verified this notion by examining its properties in a state of purity. The following process for obtaining it, is given by M. Badollier, *Ann. de Chim. et de Phys.* xvii. 273.

A pound of yellow bark, bruised small, is to be boiled for a quarter of an hour in three pints of a very dilute solution of pure potassa. The liquid, after being suffered to cool, is then to be strained through a fine cloth with pressure, and the residuum repeatedly washed and pressed. The cinchona, thus washed, is to be slightly heated in a sufficient quantity of water, adding muriatic acid gradually until litmus paper is slightly reddened. When the liquid is raised nearly to the boiling point, it is to be strained, and the cinchona again pressed. To the strained liquor, while hot, add an ounce of sulphate of magnesia, and after this add solution of potassa, till it ceases to occasion any precipitate. When the liquor is cold, collect the precipitate on a filter, wash and dry it, and dissolve it in hot alcohol. On evaporation of the alcohol, the cinchonia crystallizes in delicate prisms.

Cinchonia thus obtained is white, translucent, crystalline, and soluble in 2500 times its weight of boiling water, but a considerable part separates on cooling. Its taste is bitter, though long in being developed, owing to its insolubility; but its acid solutions have a strong taste of Peruvian bark. It is neither fusible nor volatile at moderate temperatures. It is very soluble in alcohol and ether, and sparingly so in fixed and volatile oils.

Cinchonia restores the colour of litmus, which has been reddened by an acid; unites with all the acids; and, with the greater number, forms compounds which are perfectly neutral. The sulphate is very soluble, has an intensely bitter taste, and crystallizes in four-sided prisms. The muriate is still more soluble in water than the sulphate; dissolves in alcohol; and crystallizes in delicate prisms. The nitrate is not crystallizable. The oxalate, tartrate, and gallate of cinchonia are insoluble. Hence it is that infusion of galls precipitates the decoction of cinchona. (See *Ann. de Chim. et Phys.* xv. 289, 337; xvii. 273, 316; and *Ann. of Phil. N. S.* ii. 316).

QUINIA.—This substance was discovered by Pelletier and Caventou in the bark of the *Cinchona Cordifolia*. It may be sepa-

rated by a process precisely analogous to the foregoing. It is not crystallizable, but, when dried, presents a whitish porous mass, almost insoluble in water, but extremely bitter. It is distinguished also from cinchonia by its forming, with the same acid, salts which differ as to their form, and the proportion of their elements. The sulphate of quinia is less soluble, but fully as bitter as that of cinchonia. It crystallizes in fine needles, which have the aspect of amianthus.

Both these vegetable alkalies, when decomposed by peroxide of copper, yield only water and carbonic acid, but no azote.

According to Pelletier and Caventou, the *Cinchona Condaminea* is composed of

1. Cinchonia united to kinic acid.
2. A greenish fatty matter.
3. A red insoluble matter.
4. A red soluble matter (a variety of tan).
5. Yellow colouring matter.
6. Kinate of lime.
7. Gum.
8. Starch.
9. Lignin.

The other varieties of cinchona present the same ingredients in different proportions. Vauquelin found, that those specimens of Peruvian bark possess the greatest medicinal efficacy, whose infusions are precipitated not only by infusion of nut-galls, but by solutions of gelatin, and of emetic tartar. The inefficiency of all these agents, when applied as tests to an infusion of Peruvian bark, was observed to take place only in those specimens, which experience had shown to be destitute of medicinal virtues.

Analysis of Cork by Chevreul.—Vol. II. p. 195.

CORK-wood appears, from the experiments of Chevreul, to contain several substances, which may be separated from each other by the successive action of water and alcohol, applied by means of a small Papin's digester of a peculiar construction, which he has described in the *Ann. de Chimie*, xcvi. 149. To water thus raised above its ordinary boiling point, cork gave out an aromatic principle, and a little acetic acid, which passed over into the receiver. The watery extract contained a variety of substances, viz. two colouring matters, the one yellow, the other red; an acid, the nature of which was not determined; gallic acid; an astringent matter; gallate of iron, &c. Twenty parts of cork thus treated, left 17.15 of insoluble matter, which, when digested with alcohol, yielded three distinct substances, cerin, resin, and a peculiar oil. When the alcohol was evaporated to one-sixth and set aside, the cerin separated in small white needles, not fusible in boiling water, but becoming soft and settling to the bottom. Cerin, thus ob-

tained, is, in a very small degree, more soluble than wax in alcohol, 1000 parts of boiling alcohol taking up 2.42 of cerin and only two parts of wax. Nitric acid gradually dissolves cerin, and changes it into oxalic acid. Its properties differ, therefore, from those of the substance to which the same name was given by Dr. John.

Of the 20 parts of cork-wood thus successively treated with water and alcohol, 14 parts remained undissolved. They consisted of suber, probably, however, not perfectly pure; but of its properties in that state, we have as yet no accurate knowledge. (See Ann. of Phil. ix. 52.)

Ultimate Analysis of Naphtha.—Vol. II. p. 197.

Dr. THOMSON analyzed Persian naphtha by igniting it with peroxide of copper, and obtained gaseous products indicating 82.2 carbon + 14.8 hydrogen in 100 of naphtha, leaving a deficiency of 3 per cent, which he ascribes to azote. The proportion of the atoms of carbon to those of hydrogen, best according with these experiments, would be 14 of the former to 13 of the latter.

Dr. Ure's analysis of naphtha, sp. gr. 0.857, obtained by distillation from petroleum, assigns moreover an atom of oxygen, viz.

Carbon . . .	22 atoms . . .	132 . . .	82.5
Oxygen . . .	1 ditto . . .	8 . . .	5.
Hydrogen . . .	20 ditto . . .	20 . . .	12.5
		160	100.

According to this view, naphtha should consist of 20 atoms of olefiant gas, + 1 of carbonic oxide, + 1 of free carbon. It is probable, however, that the two last elements are to be ascribed to the impurity of the specimen submitted to analysis, which seems to have had a greater specific gravity than belongs to highly rectified naphtha. This want of agreement between different results, points out the necessity of a fresh analysis of naphtha.

Properties and Analysis of the Principal Varieties of Coal found in Great Britain.—Vol. II. p. 199.

THE Wernerian arrangement of black coal into six subspecies, does not appear to Dr. Thomson applicable to the different kinds of coal, which are found in Great Britain. He proposes four subdivisions only, which he distinguishes by the following names,

1. *Caking coal*, so called because its fragments melt at a certain temperature, and unite into one mass. The coal of Newcastle, which is carried to London, and also much of the coal found in the neighbourhood of Manchester, and in various other parts of the kingdom, belong to this species.

2. *Splint coal*, or *splent coal*, which has received its name from the splintery appearance of its cross fracture. It has also been called *hard coal* from the difficulty of breaking it. It is the sort best adapted for making coke, and extracting iron from its ores; though when it cannot be obtained, other varieties of coal are applied to those purposes.

3. *Cherry coal*.—This coal abounds in the neighbourhood of Glasgow and in Staffordshire. It has considerable lustre, both in its principal fracture, which is slatey, and in its cross fracture, which is flat and conchoidal. It is of about the same degree of hardness as caking coal, and, being very easily frangible, there is considerable loss in mining it. It readily catches fire, burns with a clear yellow flame, and is consumed much faster than either of the foregoing species. It abounds in the neighbourhood of Glasgow and of Birmingham.

4. *Cannel coal* is a very well characterized species. It is found of the best quality and in the greatest abundance at Wigan in Lancashire. Its great combustibility, and the vivid light which it emits, have occasioned its being sometimes substituted for candles. As it does not at all soil the fingers, and is easily turned by a lathe, it is made into snuff-boxes, ink-stands, and various trinkets.

The fluid and gaseous substances obtained by the analysis of pit-coal are to be regarded, not as mere products which pre-existed in the coal in the same state as that in which they are evolved, but as generated by the action of heat in effecting a new arrangement of their ultimate elements. Dr. Thomson, therefore, considers the ultimate analysis of coal as alone capable of giving any satisfactory information of its nature. With this view he analyzed the different species, by combustion with peroxide of copper. The proportion of incombustible matter in each species was found to be as follows:

In 100 grains of caking coal	1.5
In 100 grains of splint coal	9.5
In 100 grains of cherry coal	10.
In 100 grains of cannel coal	11.

The quantity of coke formed, and of volatile matter dissipated, from 1000 parts, are expressed in the following Table.

From 1000 parts of	Weight of Coke.	Volatile Matter.
Caking coal	774.0	226.
Splint coal	647.3	352.7
Cherry coal	522.5	477.5
Cannel coal	400.	600.

The two following Tables exhibit the results of Dr. Thomson's analysis of the four different species of coal.

I. Constituents by Weight.

	Carbon.	Hydrogen.	Azote.	Oxygen.	Total.
Caking coal	75.28	4.18	15.96	4.58	100
Splint coal	75.00	6.25	6.25	12.50	100
Cherry coal	74.45	12.40	10.22	2.93	100
Cannel coal	64.72	21.56	13.72	0.00	100

II. Constituents in Atoms.

	Carbon.	Hydrogen.	Azote.	Oxygen.	Number of atoms.
Caking coal	33	11	3	1.5	48.5
Splint coal	28	14	1	3.5	46.5
Cherry coal	34	34	2	1	71
Cannel coal	11	22	1	0	34

Dr. Ure has given different results for splint and cannel coal (Phil. Trans. 1822, p. 471). But as azote is not included in them, and as all the specimens of these two varieties of coal, which I have ever tried, have yielded ammonia by distillation, I cannot consider the atomic constitution, which he has assigned to these two bodies, as correct. It appears to me, however, that he is nearer the true proportion of oxygen, viz. 21.05 in 100 parts of cannel coal, and 24.8 in 100 of splint coal; for the quantity of products into which oxygen enters, (water, carbonic acid, and carbonic oxide), obtained by the destructive distillation of coal, indicates a considerable proportion of that element.

Account of Naphthaline, a Peculiar Substance obtained in the Distillation of Coal Tar.—Vol II. p. 199.

THIS substance, though not a native bitumen, may be described in this place, as one of the products of the decomposition of coal. It is produced abundantly in the first and second distillations of coal tar; and separates spontaneously, especially in cold weather, from the volatile oil which comes over. After being purified as completely as possible, from the oily matter which adheres to it, by being pressed between folds of blotting paper, it may be dissolved in heated alcohol, from which it separates again on cooling. After repeated solutions and crystallizations, it is obtained in brilliant white scaly crystals, similar to benzoic acid, but of a more silvery lustre.

Naphthaline has a pungent and aromatic taste, and a penetrating smell, which adheres permanently to any substance that is brought into contact with it. It is smooth and unctuous to the touch. Its specific gravity a little exceeds that of water. It is less volatile than camphor, melts at about 180° (168° Ure) and boils at 410° Fahr. On cooling, it assumes a distinctly crystalline structure.

It is not very easily inflamed; but when set on fire, it burns with a copious dense smoke. It does not affect the colours of litmus or turmeric. It is insoluble in cold water, and very sparingly in hot water. It is readily soluble in alcohol and ether, and in both those fluids, when heated, it dissolves to almost any amount. It is soluble in fixed and essential oils; in acetic and oxalic acids, to each of which it imparts a pink colour; and in diluted mineral acids. Of all its characters, its ready disposition to crystallize is perhaps the most remarkable. These crystals are rhombic plates, the greater angle of which varies from 100° to 105° , and which are arranged so as to intersect each other and to form cells.

The only analysis of naphthaline that has been published is that of Dr. Ure. He assigns to it the following atomic constitution, but expresses some doubts as to the perfect accuracy of his results, on account of the difficulty of effecting the complete combustion of the carbon of so volatile a body. It appears to consist of

Carbon . . .	2 atoms . .	12 . .	92.9
Hydrogen . .	1 atom . .	1 . .	7.1
		<hr/>	<hr/>
		13	100.

The absence of oxygen, first pointed out by Mr. Brande, is confirmed by this analysis. (Phil. Trans. 1822, p. 473.) There can be little doubt, indeed, that naphthaline is compounded of carbon and hydrogen only.

Account of Several Peculiar Vegetable Principles.—

Vol. II. p. 204.

HÆMATIN is the colouring matter of the *Hæmatoxylin Campechianum*, or Logwood, and was first recognised by Chevreul as a distinct vegetable substance. To obtain it, digest finely ground logwood, for several hours, in water of a temperature between 120° and 130° . Let the filtered liquor be evaporated to dryness, and the residue be digested for a whole day in alcohol of sp. gr. 0.835. Filter the solution, concentrate it by evaporation, then add a little water, evaporate a little farther, and leave it to itself. Small brilliant crystals will be deposited in abundance, of a reddish-white colour, and a slightly bitter, astringent, and acrid taste. They are soluble in boiling water, and impart to it an orange-red colour, which becomes yellow when the liquid cools, but is restor-

ed by heat. The solution, on evaporation, again yields crystals of hæmatin. Acids, with the exception of the sulphurous acid, which destroys its colour, render the solution first yellow and then red. Caustic alkalies render it purplish-red, or, in large quantity, violet, then reddish-brown, and finally yellowish-brown; and the colour cannot afterwards be restored by adding acids. Hence the hæmatin is decomposed. Gelatin precipitates it from water in yellow flocks. (Ann. de Chim. lxxi. 128.)

SARCOCOLL.—This substance is the spontaneous exudation of the *Pœnea Sarcocolla*, a plant which is a native of Ethiopia. It is brought over in small pieces, which are about the size of peas, and which are either of a pale red, or yellowish-white colour.

Sarcocoll dissolves in the mouth like gum, and has a sweetish taste, after which there remains an impression of bitterness. It is soluble both in water and alcohol, and a strong solution of it forms a mucilage, which may be used for the purpose of a cement. Its most remarkable property is, that its solution is precipitated by tan, which distinguishes it sufficiently from gum. The substance, most nearly approaching to it in chemical characters, is liquorice, the saccharine matter of which has a near resemblance to sarcocoll. (See Robiquet, Ann. de Chim. lxxii. and Thomson's Chemistry, iv. 51.)

OLIVILE is a name given by M. Pelletier to the substance which remains after gently evaporating the alcoholic solution of the gum which exudes from the olive tree. It is a white brilliant starchy powder, and sometimes it forms flattened needles. It has no smell, but its taste is a mixture of bitter and sweet with something aromatic. It melts at 158°, and on cooling resembles a slightly yellowish transparent resin. Cold water scarcely acts upon it, but hot water dissolves 1-32d. It dissolves readily in alcohol, but not in ether or in volatile oils. Nitric acid dissolves it with heat, acquires a red colour, but becomes yellow on cooling and deposits oxalic acid. Acetate of lead precipitates its aqueous solution in flakes, which are soluble in acetic acid. (Ann. of Phil. xii. 33.)

MEDULLIN is a name given by Dr. John to the pith of the sunflower. (*Helianthus Annuus*.) It is destitute of taste and smell; insoluble in water, ether, alcohol, and oils, but soluble in nitric acid, which converts it into oxalic acid; and, when decomposed by destructive distillation, it leaves charcoal having a metallic lustre like bronze. (Thomson's Chemistry, iv. 180.)

LUPULIN.—This name has been given by Dr. Ives, not to any distinct vegetable principle extracted by chemical means, but to an impalpable yellow powder, in which he believes the virtue of the hop to reside, and which may be obtained by beating and sifting the hops used in brewing.

It appears to be peculiar to the female plant, and is probably secreted by the nectaria. In preserving beer from the acetous fermentation, and in communicating an agreeable flavour to it, lupulin was found to be equivalent to ten times its weight of hop

leaves. It is itself a compound substance, consisting of tan, extract, a bitter principle, wax, resin, and lignin. If analyzed by the methods of Pelletier and Caventou, it is not improbable that an ingredient might be discovered in the hop of an alkaline nature, in which its narcotic virtue would be found to reside. (See *Ann. of Phil. N. S.* i. 194.)

CATHARTIN.—In examining the leaves of Senna, Lassaigne and Fenuelle obtained a peculiar substance, to which, on account of its acting as a brisk purgative in very small doses, they gave the name of cathartin. A strained decoction of the leaves was precipitated by extract of lead, the precipitate washed and diffused through water, and then decomposed by sulphuretted hydrogen. The liquor was filtered, evaporated to dryness, digested in alcohol, and the latter solution evaporated to dryness also. It contained acetate of potassa, which was decomposed by adding alcohol acidulated with a little sulphuric acid; the sulphate of potassa was separated by filtering, and the excess of sulphuric acid separated by acetate of lead. Sulphuretted hydrogen was again passed through the liquid, which, when filtered and again evaporated, gave the substance which they have called cathartin. It had a reddish colour, a peculiar smell, and a bitter nauseous taste; it dissolved in alcohol and water in all proportions, but was insoluble in ether. It became moist by exposure to the air. (*Ann. de Chim. et Phys.* xvi. 16.)

PIPERIN has been extracted by M. Pelletier from black pepper, by digesting it in alcohol, and evaporating the solution, which left a fatty resinous matter. This, after being washed in warm water, was of a green colour, and had a hot burning taste. It dissolved readily in alcohol, and less readily in sulphuric ether, and the solution by heated alcohol, when left for some days, deposited a number of small crystals. These being purified by repeated solutions and crystallizations, gradually lost their taste of pepper, which accumulated in the uncrystallizable fatty matter. The crystals of piperin were four-sided prisms; they were almost tasteless; were insoluble in cold and sparingly soluble in hot water; were very soluble in alcohol, and less so in ether; soluble in acetic acid, from which they separated in feathery crystals. Weak acids did not dissolve, and strong acids decomposed them. Sulphuric acid acquired, by being heated with them, a blood-red colour, which disappeared on dilution. They fused at 212° , and, when decomposed by peroxide of copper, gave only water and carbonic acid.

In addition to piperin, M. Pelletier detected in pepper an acrid fixed oil; a volatile oil; a coloured gummy matter; extract, starch, and several other known vegetable principles. (*Ann. de Chim. et Phys.* xvi. 337.)

ADDITIONS TO THE CHAPTER ON THE RESULT OF THE
SPONTANEOUS DECOMPOSITION OF VEGETABLE
SUBSTANCES.—PART I. CHAP. XXI.

Specific Gravity of Alcohol, at Various Terms of Dilution.—
Vol. II. p. 209.

It is on many occasions useful to know the proportion of the strongest alcohol that has hitherto been obtained, in mixtures of alcohol and water of different specific gravities. This is shown by the following Table, constructed by Lovitz. It is founded on a series of experiments in which alcohol of the sp. gr. .791 at 68° was mixed with various proportions of water; allowed to stand during 24 hours; and then examined for its sp. gr. at the temperature of 68°. The fourth column has been added by Dr. Thomson, to express the sp. gr. at 60°, the temperature commonly preferred in this country.

TABLE OF THE STRENGTH OF ALCOHOL OF VARIOUS DENSITIES.

100 Parts.		Sp. Gravity.		100 Parts.		Sp. Gravity.	
Alcoh.	Wat.	at 68°.	at 60°.	Alcoh.	Wat.	at 68°.	at 60°.
100	—	791	796	83	17	836	840
99	1	794	798	82	18	839	843
98	2	797	801	81	19	842	846
97	3	800	804	80	20	844	848
96	4	803	807	79	21	847	851
95	5	805	809	78	22	849	853
94	6	808	812	77	23	851	855
93	7	811	815	76	24	853	857
92	8	813	817	75	25	856	860
91	9	816	820	74	26	859	863
90	10	818	822	73	27	861	865
89	11	821	825	72	28	863	867
88	12	823	827	71	29	866	870
87	13	826	830	70	30	868	871
86	14	828	832	69	31	870	874
85	15	831	835	68	32	872	875
84	16	834	838	67	33	875	879

TABLE CONTINUED.

100 Parts.		Sp. Gravity.		100 Parts.		Sp. Gravity.	
Alcoh.	Wat.	at 68°.	at 60°.	Alcoh.	Wat.	at 68°.	at 60°.
66	34	877	880	32	68	952	955
65	35	880	883	31	69	954	957
64	36	882	886	30	70	956	958
63	37	885	889	29	71	957	960
62	38	887	891	28	72	959	962
61	39	889	893	27	73	961	963
60	40	892	896	26	74	963	965
59	41	894	898	25	75	965	967
58	42	896	900	24	76	966	968
57	43	899	903	23	77	968	970
56	44	901	904	22	78	970	972
55	45	903	906	21	79	971	973
54	46	905	908	20	80	973	974
53	47	907	910	19	81	974	975
52	48	909	912	18	82	976	
51	49	912	915	17	83	977	
50	50	914	917	16	84	978	
49	51	917	920	15	85	980	
48	52	919	922	14	86	981	
47	53	921	924	13	87	983	
46	54	923	926	12	88	985	
45	55	925	928	11	89	986	
44	56	927	930	10	90	987	
43	57	930	933	9	91	988	
42	58	932	935	8	92	989	
41	59	934	937	7	93	991	
40	60	936	939	6	94	992	
39	61	938	941	5	95	994	
38	62	940	943	4	96	995	
37	63	942	945	3	97	997	
36	64	944	947	2	98	998	
35	65	946	949	1	99	999	
34	66	948	951	—	100	1000	
33	67	950	953				

Diminution in Bulk of Alcohol and Water on Mixture.—

Vol. II. p. 209.

THIS diminution is best shown by a contrivance of Dr. Marcet, represented inverted in the sketch at the top of the next page. It

consists of a glass vessel, formed of two spherical bulbs connected together, and terminating in a tube, about 12 inches long, which is hermetically sealed at the lower end. The upper bulb has a neck and ground stopper. The tube and lower bulb are first to be filled with water, and the upper bulb with alcohol. The stopper being put into its place, the instrument is to be inverted, as shown in the figure; when the two fluids will unite; heat will be evolved; and on cooling to their original temperature, an empty space will be seen in the tube. The same instrument may be employed to show the diminution of bulk in sulphuric acid and other fluids by mixture with water.



An exception to this law is stated by Thenard (*Traité de Chim.* iii. 309) in alcohol of density 0.9707; for 5 parts of this alcohol, mixed with five of distilled water, give a mixture of sp. gr. 0.9835, which is less than the mean (0.9854) of the alcohol and water before mixture. Hence, in this case, there must have been a dilatation of volume.

Production of Cold by the Evaporation of Alcohol.—
Vol. II. p. 209.

ALCOHOL is extremely volatile, and produces considerable cold by its evaporation. When a thermometer, after being immersed in spirit of wine, is suspended in the air, the quicksilver sinks two or three degrees. By repeated dippings and exposures, and by blowing upon the bulb with a pair of bellows, Dr. Cullen caused the thermometer to sink from 44° to below the freezing point. It has been found, that the degrees of cold, produced by the evaporation of spirits, are proportional to the strength of the spirits. Thus, if a certain degree of cold be produced by water, and another degree by alcohol, a spirit of half strength will give a degree of cold just half way between the two. (*Quart. Jour.* x. 187.)

*Ultimate Analysis of Alcohol.—*Vol. II. p. 212.

THE most elaborate series of experiments on the composition of alcohol, is that of Saussure, junior, (*Nicholson's Journal*, xxi.; or *Ann. de Chim.* lxxxix.) He employed several different methods; but that, on which he placed most reliance, was a careful analysis of the products obtained by transmitting alcohol through a red-hot

porcelain tube. The general result of these experiments was, that alcohol, sp. gr. 0.792 at 68°, consists of

Carbon	51.98
Oxygen	34.32
Hydrogen	13.70

100.

The atomic constitution most nearly agreeing with this statement, is the following; and the close coincidence between the experimental results, and the numbers in the last column, strongly confirms its probability.

Carbon	2 atoms	12	52.17
Oxygen	1 ditto	8	34.79
Hydrogen	3 ditto	3	13.04
				<hr/>		<hr/>
				23		100.

Dr. Ure has analyzed alcohol by combustion with peroxide of copper, and found it composed of

Carbon	3 atoms	18	46.15
Oxygen	2 ditto	16	40.03
Hydrogen	5 ditto	5	12.82
				<hr/>		<hr/>
				39		100.

His alcohol, however, had the sp. gr. 0.812, and must therefore have contained 6 per cent. of water. Excluding this, 100 parts of sp. gr. .792, must have been composed of

Carbon	49.10
Oxygen	36.81
Hydrogen	14.09

100.

We may consider, then, the accuracy of Saussure's experiments as standing unimpeached, and the most probable constitution of alcohol to be 2 atoms of carbon, + 1 of oxygen, + 3 of hydrogen. But in order to compare its composition with that of ether, it will be found more convenient to double these numbers, and to consider alcohol as represented by

Carbon	4 atoms	24
Oxygen	2 ditto	16
Hydrogen	6 ditto	6
				<hr/>
				46

The two atoms of oxygen are probably associated with two atoms of hydrogen, composing two atoms of water; and the remaining four atoms of hydrogen with four atoms of carbon, forming four

atoms of olefiant gas. We may consider alcohol, then, as constituted of

Olefiant gas . . .	4 atoms . . .	$7 + 4 = 28$. . .	100.
Aqueous vapour . .	2 ditto . . .	$9 + 2 = 18$. . .	64.29

Weight of the atom of alcohol 46

And 100 parts by weight of alcohol consist of

Olefiant gas	60.87
Aqueous vapour	39.13
	<hr/>
	100.

Additional Processes for obtaining Nitric Ether.—Vol. II. p. 215.

By the distillation of crystallized nitrate of lead, a yellow coloured liquid is obtained, which is nitrous acid, nearly, if not entirely, free from water. When pure alcohol and this fluid are mixed together by a little at a time, to obviate as much as possible the violent heat which is evolved, nitric ether is formed at once; and this is, perhaps, the best way of preparing it. (Ann. of Phil. xvi. 32.)

Bouillon Lagrange has proposed the following process: Mix together in a matrass equal weights of alcohol and nitric acid. Saturate this mixture when cold with nitrous gas produced in the usual way. To the matrass are to be luted a series of Woulfe's bottles, each half filled with a saturated solution of common salt. The mixture gradually becomes hot, and after some time even boils. At this time the Woulfe's bottles must be surrounded by a freezing mixture. All the nitric ether, amounting to 3 ounces from 8 ounces of alcohol, will be found floating on the surface of the solution in the second bottle. (Ditto.)

Preparation of Fluoboric and Hydriodic Ethers.—Vol. II. p. 216.

Fluoboric Ether.—When a current of fluoboric gas is passed into alcohol, the latter acquires an ethereal odour, and emits fumes. The liquid rectified first from potassa, and afterwards from chloride of calcium, is analogous to sulphuric ether, burns like it, and without acid fumes. Its specific gravity is 0.75, when not purified by washing with water. As it does not essentially contain any of the acid employed in forming it, it may be ranked with those produced by sulphuric, phosphoric, and arsenic acids. Its formation appears to be owing to the affinity of fluoboric acid for water. It

is not accompanied by the production of sweet oil of wine, as in the case of sulphuric ether.

Hydriodic ether was first prepared by Gay-Lussac by the distillation of equal volumes of alcohol and of hydriodic acid, sp. gr. 1.700. This ether does not redden litmus; its sp. gr. at 72° Fahr. is 1.9206; it boils at 148°, but cannot be set on fire by bringing an inflamed body near its surface. By keeping, it acquires in a few days a rose colour from the disengagement of a little iodine.

Composition of the Sulphuric Ether of the Shops.—Vol. II. p. 217.

THE specific gravity of ether, as found in the shops, is seldom less than .750. It is in fact a mixture of ether and alcohol. The following Table has been constructed by Mr. Dalton from direct experiments on mixtures of ether, sp. gr. .720, with alcohol of sp. gr. .830.

TABLE OF THE SPECIFIC GRAVITIES OF MIXTURES OF ETHER
AND ALCOHOL.

Ether.	Alcohol.	Sp. Gr.
100 +	0	0.720
90 +	10	0.732
80 +	20	0.744
70 +	30	0.756
60 +	40	0.768
50 +	50	0.780
40 +	60	0.792
30 +	70	0.804
20 +	80	0.816
10 +	90	0.828
0 +	100	0.830

From this Table, it should appear that the rectified ether of the shops, sp. gr. 0.750, contains about 25 per cent. by weight of alcohol, and the unrectified ether from 55 to 60 of alcohol, the ethereal portion having the sp. gr. .720.

Force of the Vapour of Ether.—Vol. II. p. 217.

THE force of the vapour of ether may be beautifully shown by letting up a drop or two of sulphuric ether into the vacuum of a common barometer, when it will instantly depress the mercury several inches, more or less, according to the temperature. It is easy to know in this way what force the vapour of ether will at

any time acquire in air; since its force is always just the same in air as in a vacuum at a given temperature. Suppose its force in vacuo, when the barometer stands at 30, to be 10 inches, then $\frac{30}{10} = 1.5$; that is, if ether be passed up into air under those circumstances, it will in due time increase the volume of air 50 per cent. This, however, is true only of pure ether; for if impure ether be passed through water, it is improved in quality, though diminished in quantity. (Dalton.)

When gases, mingled with the vapour of ether, are confined by dry mercury, they may be kept over it without sustaining any loss. But they cannot be kept over alcohol without sustaining a rapid loss of ethereal vapour. Over water, there is a loss also, but much less rapid.

The force of the vapour of ether at different temperatures has been investigated by Mr. Dalton and by Dr. Ure; but the results of the latter are objectionable, on account of the impurity of the ether which he employed. Mr. Dalton has given the following Table, showing the force of ethereal vapour at a few temperatures:

Temperatures in degrees of Fahr.	Force of Ethereal Vapour.
36°	7.5 inches.
64	15.
96	30.
132	60.
173	120.
220	240.

The experiments, on which the foregoing Table is founded, were not carried further than 212°, but as that temperature gives a force of 207 or 209 inches, the force at 220 may be inferred to be 240.

The boiling point of mixtures of ether and alcohol, Mr. Dalton found, may be made to vary from 96° to 176°; but we cannot, from the proportions of any mixture, infer what will be the boiling point, which is always much nearer that of ether than the proportions would indicate.

Ultimate Analysis of Sulphuric Ether:—Rationale of the Conversion of Alcohol into Ether.—Vol. II. p. 220.

DR. URE has analyzed ether, sp. gr. .700, by igniting it with peroxide of copper, and finds it to consist of

Carbon	3 atoms	18	60.00
Oxygen	1 ditto	8	26.66
Hydrogen	4 ditto	4	13.34

30

100.

[On the supposition that Ether is constituted of two volumes of olefiant gas, and one volume of aqueous vapour, its composition by weight would be]

Olefiant gas . . .	4 atoms . . .	$7 \times 4 =$	28
Aqueous vapour . . .	1 ditto . . .		9
			<hr/> 37

Or,

Carbon . . .	4 atoms . . .	24 . . .	64.86
Oxygen . . .	1 ditto . . .	8 . . .	21.62
Hydrogen . . .	5 ditto . . .	5 . . .	13.52
			<hr/> 37
			<hr/> 100.

Contrasting, then, the composition of alcohol and that of ether, it will be easy to perceive what takes place when the former is converted into the latter.

Alcohol consists of	Ether consists of
Olefiant gas . . . 4 atoms	Olefiant gas . . . 4 atoms
Aqueous vapour . . . 2 ditto	Aqueous vapour . . . 1 atom

Or, in volumes,	In volumes,
Olefiant gas . . . 4 volumes	Olefiant gas . . . 4 volumes
Aqueous vapour . . . 4 ditto	Aqueous vapour . . . 2 ditto

To change alcohol into ether, all that is necessary is to take away one atom, or two volumes, of aqueous vapour; and in this removal of one-half the water, which forms an element of alcohol, it seems to be universally agreed that etherification consists, even among those who differ as to the precise number of atoms constituting those fluids. If then the conversion could be made without any loss, 46 parts of absolute alcohol should give 37 parts of ether, or 100 parts by weight of alcohol should give very nearly 80½ of ether, a proportion, which, owing to a variety of causes, can never be obtained in practice.

When we act upon alcohol with a proportion of sulphuric acid sufficient to take away the whole of the water, we obtain little or no ether. Olefiant gas is in this case the principal product, mixed, however, with some sulphurous and carbonic acid gases, which are formed by the too energetic action of the sulphuric acid on the carbon of the alcohol. We can at pleasure then convert alco-

bol either into ether or olefiant gas, though neither of those products is wholly unaccompanied by others, resulting from a still farther decomposition of that fluid into its ultimate elements.

Mr. Phillips's Process for obtaining Acetic Acid.—
Vol. II. p. 223.

MR. PHILLIPS has described an outline of the following process, as a good and economical method of preparing acetic acid: dissolve 10 ounces of acetate of lead (equivalent to about $4\frac{1}{2}$ ounces of dry acetate of lime, which may be substituted if more convenient) in two pints of distilled or rain water, and add to the heated solution $8\frac{1}{2}$ ounces of crystallized sulphate of soda, dissolved in a pint of boiling water. Mix the two solutions, which will be mutually decomposed. An acetate of soda will be formed, and may be decanted or drained through a cloth, from the precipitated sulphate of lead or lime. Evaporate the solution to dryness, taking care to employ a moderate heat at the last; reduce it to powder; and put it into a retort, with three ounces of sulphuric acid, diluted previously with an ounce of water. By distillation at a gentle heat, about $5\frac{1}{2}$ ounces of acetic acid will be obtained, containing 42 per cent. of real acetic acid. The contamination of the product with a little sulphurous acid is not easily discovered by the smell, on account of the strong odour of the acetic acid; but it is easily discriminated, on drawing a little of the vapour into the lungs, by its causing a sensation like that produced by breathing the fumes of burning brimstone. In this case, the acid must be re-distilled from $\frac{1}{18}$ th or $\frac{1}{20}$ th its weight of acetate of lead. By using very dry acetate of soda, and very concentrated sulphuric acid, the product will contain, when rectified, 65 or 66 per cent. of real acetic acid; and it may be further strengthened by allowing it to congeal at a low temperature. The congealed portion, when drained from the fluid, and melted, will be found increased in acidity to upwards of 80 per cent.

The sulphate of soda may be washed out of the retort with a little warm water, and used again for decomposing a similar quantity of acetate of lead or acetate of lime: but if the solution contain much uncombined sulphuric acid, it will be advisable to boil it dry, and to heat the dry salt sufficiently to expel the redundant acid, before applying it to effect a fresh decomposition. (*Ann. of Phil. N. S.* ii. 23.)

Atomic Constitution of Acetic Acid.—Vol. II. p. 224.

THE most probable constitution of acetic acid, derived from the analysis of its salts, is the following:

Carbon . . .	4 atoms . . .	24 . . .	48
Oxygen . . .	3 ditto . . .	24 . . .	48
Hydrogen . .	2 ditto . . .	2 . . .	4
		<hr/>	
		50	100

Its equivalent, according to this view of its composition, is 50.

Means of ascertaining the Strength of Acetic Acid.—
Vol. II. p. 225.

THE strength of acetic acid not being accurately represented by its specific gravity, it had long been desirable to find a test, which should express its degree of acidity with uniform correctness. This, it is evident, may be done by determining the quantity of alkaline or earthy substances, required for its saturation; for the stronger the acid, the greater the quantity of any alkali or earth, which it will be capable of neutralizing. One hundred parts by weight of real acetic acid are found to neutralize 290 of crystallized, = 107.7 parts of anhydrous, carbonate (or sub-carbonate) of soda. It is easy, then, after ascertaining the quantity of carbonate of soda, which any specimen of acetic acid is capable of neutralizing, to calculate its strength by the rule of proportions; or if any other alkaline or earthy compound be preferred, as a test, to carbonate of soda, the scale of equivalents will at once show how much should be employed of the test which may be substituted.

In the *acetometer*, invented by Messrs. J. and P. Taylor, which has been adopted by the Excise, for determining the rate of duty on vinegar, hydrate of lime is employed to saturate the acid, and the specific gravity of the resulting solution of acetate of lime is made the measure of the strength of the acid. Vinegar, containing 5 parts of real acid in 100 parts by weight, or saturating 14.5 of crystals of carbonate of soda, (the kind called by the London Vinegar Makers, No. 24), is taken as a standard; and when neutralized by hydrate of lime, an hydrometer stands in it at the mark on the stem which is called *proof*. To keep the stem of the instrument at the same mark, when immersed in stronger acids saturated with lime, it is loaded with a series of weights, each of which indicates 5 per cent. of acid above proof, up to 35, which of course contains 5 + 35 = 40 per cent. of real acetic acid. (Quart. Journ. vi. 255.) This is the greatest strength at which the duty is levied by the gallon, that on stronger acids being regulated in a different manner.

ADDITIONS TO THE CHAPTER ON ANIMAL SUBSTANCES.—
PART I. CHAP. XXII.

Conversion of Gelatin into Sugar, by the Action of Sulphuric Acid.—Vol. II. p. 230.

THE most remarkable effect on gelatin is produced by sulphuric acid, by which Braconnot has discovered that it is converted into a substance analogous to sugar. Twelve parts of powdered glue were mixed by stirring with 24 of concentrated sulphuric acid. In 24 hours, the liquor had not changed colour; about thrice as much water was added; and the whole boiled for five hours, adding water at intervals to supply the waste. The solution was saturated with chalk, filtered and left to evaporate spontaneously. In the course of a week, it yielded crystals of a very sweet taste, which, when washed in weak alcohol, pressed in a cloth, re-dissolved, and re-crystallized, were tolerably pure sugar.

This sugar differs from cane sugar in being much more readily crystallized. It is equal in sweetness to grape sugar, and not more soluble in water than sugar of milk. Its solution does not ferment with yeast. When distilled at a red heat, it yields ammonia among other products.

Sugar, obtained from gelatin, appears to be capable of uniting with nitric acid without decomposition, and of affording a peculiar crystallizable compound. Its formation by sulphuric acid seems to be owing to the abstraction, from the gelatin, of hydrogen and nitrogen in the proportions fit to form ammonia, and probably in the absorption of oxygen. (Ann. de Chim. et Phys. xiii.; Quart. Journ. ix. 392.)

Atomic Constitution of Gelatin.—Vol. II. p. 231.

THE atomic proportions, most nearly approaching to the results of Gay-Lussac and Thenard, are

Carbon	. . .	15 atoms	. . .	90	. . .	50.00
Oxygen	. . .	6 ditto	. . .	48	. . .	26.67
Hydrogen	. . .	14 ditto	. . .	14	. . .	7.78
Azote	. . .	2 ditto	. . .	28	. . .	15.55
				<hr/>		<hr/>
				180		100.

Atomic Constitution of Albumen.—Vol. II. p. 235.

THE nearest atomic approximation of the proportions, obtained by Gay-Lussac and Thenard, is the following:

Carbon . . .	17 atoms . .	102 . .	53.40
Oxygen . . .	6 ditto . .	48 . .	25.13
Hydrogen . .	13 ditto . .	13 . .	6.80
Nitrogen . .	2 ditto . .	28 . .	14.67
		<hr/>	
		191	100.

It should appear, then, that albumen contains two atoms more of carbon, and one less of hydrogen, than are present in gelatin. Dr. Prout, however, who has analyzed albumen with great care, and has made many interesting observations on its formation by the process of animal digestion, (*Ann. of Phil.* xiii.), found it to be constituted as follows:

Carbon . . .	15 atoms . .	90 . .	50.00
Oxygen . . .	6 ditto . .	48 . .	26.67
Hydrogen . .	14 ditto . .	14 . .	7.78
Azote . . .	2 ditto . .	28 . .	15.55
		<hr/>	
		180	100.

But this, it may be observed, is precisely the composition of gelatin, deducible from Gay-Lussac and Thenard's analysis. Either, therefore, the analytical results must be erroneous in one or both cases; or, the difference between albumen and gelatin must consist entirely in the grouping or arrangement of elements similar as to kind and number.

Besides perfectly formed albumen, Dr. Prout has noticed a fluid approaching it in characters, to which he has given the name of *incipient albumen*. It appears to be that substance not completely elaborated, but requiring a further change by the processes of digestion and assimilation. (*Ann. of Phil.* xv. 25, 274.)

Action of Sulphuric Acid on Muscular Fibre.—Vol. II. p. 238.

THE action of sulphuric acid on muscular fibre has been attentively examined by Braconnot. A portion of beef in small shreds was steeped in water, washed several times, and pressed to separate every thing soluble. Of this fibre, 30 parts were mixed with an equal weight of sulphuric acid, which softened and dissolved it, without acquiring colour or evolving sulphurous acid. It was gently heated, and, on cooling, a layer of fat separated from the surface. It was then diluted with water, and boiled nine hours; saturated with chalk, filtered, and evaporated. No sugar was produced, but the extract had a decided taste of osmazome. It was

boiled with alcohol, which, on cooling, deposited a peculiar white matter, called by Braconnot *leucine*.

In order to purify this new substance, it was dissolved in water, and a little tan added. After some hours, the liquor was filtered, and evaporated till a pellicle appeared. Being then left to stand for 24 hours, the bottom of the vessel was covered with small mamillated crystals of a dull white colour, feeling brittle between the teeth, but having an agreeable taste of meat.

Leucine is lighter than water. When heated in a retort, it melts, then sublimes in part, and forms white opaque crystals, and an empyreumatic and acid fluid distils over. By the action of nitric acid on leucine, a distinct compound appears to be formed, which affords peculiar salts with the different bases. (*Quarterly Journal*, ix. 394.)

Atomic Constitution of Fibrin.—Vol. II. p. 239.

According to the results of Gay-Lussac and Thenard, its atomic constitution is

Carbon	. . .	18 atoms	. . .	108
Oxygen	. . .	5 ditto	. . .	40
Hydrogen	. .	14 ditto	. . .	14
Azote	. . .	3 ditto	. . .	42

204

It contains then an atom more of carbon, hydrogen, and azote, and an atom less of oxygen, than enter into the constitution of albumen.

Dr. Prout's Method of detecting an Excess of Urea in Morbid Urine.—Vol. II. p. 241.

In some states of disease, the urine abounds so much in urea, as to afford scales with nitric acid. To detect it, Dr. Prout puts a little of the morbid urine into a watch glass, and by means of a dropping tube introduces a little strong nitric acid under it. If spontaneous crystallization occur, an excess of urea is indicated, and its amount may be estimated by the time required for its production, which varies from a few minutes to two or three hours.

Account of Several Animal Resins.—Vol. II. p. 243.

Cerumen, or Ear-wax, has an orange-yellow colour and a bitter taste. It melts at a gentle heat, and sinks into paper like an oil.

It is extremely combustible, and burns away with a white smoke, emitting an ammoniacal odour, and leaving very little charcoal.

With water, it forms by agitation a sort of emulsion; alcohol dissolves $\frac{1}{4}$ ths of it, and the remainder has the properties of albumen. The alcoholic solution, when evaporated, leaves a deep orange residuum, which is very bitter and resembles the resin of bile. Ether also dissolves cerumen, but the solution is less highly coloured than that in alcohol.

Ambergris is found floating on the sea within the tropics, sometimes in large masses, and its origin is still matter of conjecture. Though hitherto arranged among animal resins, yet it appears to consist, according to Pelletier and Caventou, chiefly of a substance analogous to that found by Chevreul in biliary calculi, and called by him, *cholesterine*. To this matter, as obtained from ambergris, Pelletier and Caventou have given the name of *ambreine*. It may be extracted by digesting ambergris in hot alcohol of sp. gr. 0.827. On cooling, the alcohol deposits the ambreine in very bulky irregular crystals. It softens at 77° , melts at 86° , and, when raised a little above 212° , flies off in a white smoke. It is not capable of uniting with alkalies so as to form soap.

Ambreine, by being heated with nitric acid, is converted into a peculiar acid, to which the name of *ambreic acid* has been given. It is yellow while in a mass, but when spread thin is almost white. It has a peculiar smell, and reddens vegetable blues. It is not fusible, even when heated to 212° . It is very sparingly soluble in water, but dissolves copiously in alcohol and ether. It unites with potassa, and forms a salt which gives a yellow precipitate with muriates of lime and baryta, sulphates of copper and silver, muriates of tin and gold, and some other metallic salts. (Ann. of Phil. xvi. 93.)

Castor is found in two small bags in the inguinal regions of the beaver. It is of a yellow colour, and, when fresh extracted, nearly fluid; but by exposure to the air, it hardens, and acquires a resinous appearance. Its principal ingredient is a resin, which appears to be analogous to the resin of bile. It contains also carbonates of potassa, lime, and ammonia, mucilaginous extractive matter, and a volatile oil on which its odour seems to depend.

Account of the Oils, furnished by the Whale.—Vol. II. p. 244.

Whale Oil, or Train Oil, is extracted from the blubber of the whale, which is originally a firm solid fat, but on reaching this climate, is found to be mostly resolved into a fluid. To obtain the oil, the blubber is melted in large copper vessels, under which a fire is made. Beside the oil, a quantity of water separates, and on the surface there floats a solid matter called *fenks*, which is probably coagulated albumen. The more moderate the heat, and the shorter its duration, the paler and better is the oil, but this

occasions a smaller quantity to be produced. The deep colour is owing partly to too great heat in the boiling, and partly to blood and other impurities which are unavoidably mixed with it. What is extracted in Greenland is perfectly pale and limpid, and free from smell, and burns with a much purer and brighter flame than what is made in this country. In the early period of the Greenland fishery, the blubber was converted into oil in those regions; but the site of the fishery is now so much changed, and its extent so much increased, as to render this no longer practicable. (Scoresby's Arctic Regions.)

Whale oil requires to be kept in close vessels to prevent the action of the air, which seems in time to injure it. It is rendered more fluid and combustible by adding a little cold drawn linseed oil; but it cannot be made so fit for burning in lamps as spermaceti oil. Perhaps the best way of using it will be found to be the converting it into oil gas. [See page 53 of this Supplement.] For burning in lamps, it may be deprived of its offensive odour by several processes described by Mr. Dossie in the 15th vol. of the Phil. Mag.

The specific gravity of whale oil is 0.9191. It boils at 640° , and may be distilled over; but its properties are then materially altered, or rather it becomes a new substance, its specific gravity being diminished to 0.868, its boiling point lowered, and its inflammability much increased. By long continued heat, without being volatilized, it undergoes changes which have been described in the 54th vol. of the Phil. Mag. and also by Dr. Bostock, in the Ann. of Phil. N. S. i. 47.

Dr. Thomson analyzed whale oil, and found it to consist of

Carbon	. . . 12 atoms	. . . 72	. . . 68.87
Oxygen	. . . 2 ditto	. . . 16	. . . 16.10
Hydrogen	. . . 17 ditto	. . . 17	. . . 15.03
		<hr/>	<hr/>
		105	100.

Sperm Oil, or *Spermaceti Oil*, forms part of the oily substance found in the cranium of the *physeter macrocephalus*, or spermaceti whale. The oil is separated by putting the mass into a woollen bag and pressing it, by which the oil is made to run out, and the solid residue, when washed with a weak alkaline ley, affords spermaceti.

Spermaceti oil is much purer than train oil, and burns away without leaving any charcoal on the wicks of lamps. It has been decomposed by Dr. Ure, by peroxide of copper, and found to consist of

Carbon	. . . 10 atoms	. . . 60	. . . 78.00
Oxygen	. . . 1 ditto	. . . 8	. . . 10.20
Hydrogen	. . . 9 ditto	. . . 9	. . . 11.80
		<hr/>	<hr/>
		77	100.

Account of Pyro-uric, Purpuric and Erythric Acids.—
Vol. II. p. 248.

Pyro-uric Acid. This acid, the existence of which had been hinted by Scheele, and some of its compounds examined by myself, has been fully investigated by Chevallier and Lassaigue. (Ann. of Phil. xvi. 25.) They dissolved the yellow sublimate (noticed in parag. No. 3, of the article on uric acid.—See vol. II. p. 248 of the body of the work) in water, and added sub-acetate of lead. A white precipitate was obtained, which, after being washed with water, was decomposed by sulphuretted hydrogen gas. The liquid, when filtered and evaporated, yielded small white needles which were pure pyro-uric acid.

Of this acid, cold water dissolves about one-fourth of its weight, and the solution reddens vegetable blues. It dissolves in boiling alcohol, and separates, as the solution cools, in small white grains. When heated, it melts, and sublimes entirely in white needles. By being passed through a red-hot glass tube, it is decomposed, and converted into the common products of animal matter. It dissolves in nitric acid, and, by evaporation of the acid, is obtained unaltered, a character sufficiently distinguishing it from uric acid, which, when thus treated, yields purpurate of ammonia.

With lime, pyro-uric acid forms a crystallizable salt, which melts on applying heat, and assumes, on cooling, the consistence of yellow wax. It is constituted of 91.4 acid + 8.6 base. Potassa, soda, and ammonia, form with it soluble salts, the two first of which are crystallizable. Its compound with baryta is very sparingly soluble. Its alkaline salts precipitate peroxide of iron yellow; that of copper, bluish-white; and the oxides of mercury, silver, and lead, quite white.

When analyzed by combustion with peroxide of copper, it afforded

Carbon	. . .	12 atoms	. . .	72	. . .	28.29
Oxygen	. . .	14 ditto	. . .	112	. . .	44.32
Hydrogen	. . .	25 ditto	. . .	25	. . .	10.
Azote	. . .	3 ditto	. . .	42	. . .	16.84
				<hr/>		<hr/>
				251		100.

In this analysis, the products, it may be observed, fall short of the original acid by 0.55 per cent.

Purpuric Acid.—When to a solution of pure uric acid in diluted nitric acid, ammonia is added, so as to neutralize the excess of acid, and the solution is slowly evaporated, its colour gradually becomes of a deeper purple, and dark red crystals soon begin to separate in abundance. These may be dissolved in dilute solution of potassa, and heat applied to the solution till the red colour entirely disappears. The alkaline solution is then to be gradually

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dropped into diluted sulphuric acid, which saturates both the potassa and ammonia, and precipitates a peculiar acid in the form of a very fine powder, of a slightly yellowish or cream colour, exhibiting a pearly lustre when viewed by a magnifier, and destitute both of smell and taste. It is of greater specific gravity than water, though, from its minute state of division, it subsides very slowly. This powder is the purpuric acid; a title assigned to it by Dr. Prout from its power of saturating alkalies, though it is not capable of reddening litmus.

Purpuric acid is very little soluble in water. 1000 grains of which do not dissolve $\frac{1}{16}$ th of a grain, but the water assumes a purple tint, which it retains when cold. It is insoluble in ether, alcohol, dilute mineral acids, and solutions of oxalic, citric, and tartaric acids. Concentrated mineral acids, and strong alkaline solutions, dissolve it readily. Strong nitric acid decomposes it with heat, and a purple compound is obtained by evaporation to dryness, precisely as if uric acid had been dissolved.

Purpuric acid expels carbonic acid from the alkaline carbonates by the assistance of heat, and affords a class of compounds called purpurates. The aqueous solutions of these salts have a beautiful deep carmine or rose-red colour, from which property the specific name of the acid has been derived. This colour is perhaps best shown in purpurate of ammonia, which Dr. Prout supposes to constitute the colouring ingredient of the pink sediment, deposited from the urine of persons labouring under fevers.

By the combustion of purpuric acid with peroxide of copper, Dr. Prout determined it to consist of

Carbon	. .	2 atoms	. .	12	. .	27.27
Oxygen	. .	2 ditto	. .	16	. .	36.36
Hydrogen	. .	2 ditto	. .	2	. .	4.54
Azote	. .	1 ditto	. .	14	. .	31.81
				44		100.

Erythric Acid.—An acid has also been obtained by Brugnatelli, by acting on uric acid with nitric acid, which he has proposed to call *erythric acid* (from *spotpurpur*, to redden) and its compounds *erythrates*. (Phil. Mag. lii. 30.) This compound differs, however, essentially from the purpuric acid of Dr. Prout. It may be formed by dissolving pure uric acid in a slight excess of nitric acid, evaporating slowly, and putting the solution by to crystallize in a cool place. These crystals Dr. Prout supposes to be either a compound of super-nitrate and super-purpurate of ammonia, or a simple compound of nitric and purpuric acids. (Ann. of Phil. xiv. 363.) They turn slowly to a purple colour on exposure to the air, or more rapidly if dissolved in water and mixed with a few drops of liquid ammonia.

Atomic Constitution of Sacclactic Acid.—Vol. II. p. 250.

BERZELIUS has determined the composition of this acid to be

Carbon	33.430
Oxygen	61.465
Hydrogen	5.105

100.

Calculating on these results, sacclactic acid should consist of

Carbon	6 atoms . .	36 . .	34.28
Oxygen	8 ditto . .	64 . .	60.95
Hydrogen . . .	5 ditto . .	5 . .	4.77

105

100.

Saclactate of lead has also been analyzed by Berzelius, and with a result which confirms the above equivalent number. It was found to consist of 100 saclactic acid + 106.87 protoxide of lead, numbers which have as nearly as possible the proportion of 105 to 112, the equivalent of the protoxide.

Properties and Nature of Prussian Blue.—Vol. II. p. 252.

PRUSSIAN blue is insoluble in water, and in acids, unless when they are concentrated and heated. When thoroughly dried, it shows a great affinity for moisture, by absorbing it rapidly from the atmosphere. It is not decomposed by being heated to 307° Fahr.; but, at a higher temperature, it catches fire, and burns in the manner of tinder, leaving from 54 to 60 per cent. of oxide of iron.

When prussian blue in fine powder is added to a heated solution of potassa, a hydrated peroxide of iron is separated, the colour of which is not a bad indicator of the value of the pigment used in the arts; for its excellence bears a proportion to the deep redness of the oxide. The liquor is a solution of the salt, called *ferrocyanate of potassa*.

When prussian blue is kept in contact with water and iron filings, or with sulphuretted hydrogen, it is decomposed, in consequence of the de-oxidation of the iron, and reduced to the state of the white compound: but this again becomes blue on restoring oxygen.

Pure prussian blue, added to concentrated sulphuric acid, increases in volume, and becomes white; but its colour is restored on adding a sufficiency of water. Muriatic acid has no action on it, unless when concentrated and heated, and then (as Robiquet has shown, *Ann. de Ch. et Phys.* xii. 284) it separates the greater part of the oxide of iron, leaving a crystallizable substance, analo-

gous to that which is obtained by decomposing ferro-cyanate of potassa by tartaric acid, and which Mr. Porrett has termed *ferru-retted chyazic acid*.

Besides prussian blue, there appears, from Berzelius's experiments, (Ann. of Phil. N. S. i. 444), to be another blue compound of the same elements, which is soluble to some extent in water. Prussian blue, in the dingy green state in which it is first precipitated by *lixivium sanguinis*, seems also to contain an excess of base, which muriatic acid removes. There are probably, therefore, three compounds in which the peroxide, and one in which the protoxide, exists as the base.

Prussian blue submitted to distillation *per se* gives water, hydro-cyanate of ammonia, carbonic acid, and other gases.

Respecting the nature of prussian blue, a variety of opinions have been entertained, and it is still a subject on which chemists are by no means agreed. No theory respecting it can be entitled to notice that was anterior to Gay-Lussac's important discovery of cyanogen. His researches led him to believe, that prussian blue is a compound of cyanogen with a ferruginous base, and that it is, therefore, not a prussiate, but a *cyanide*; but Vauquelin, having directed his attention to this part of the subject, was still induced to regard it as a true prussiate. According to Mr. Porrett's view, it is a compound of ferro-cyanic acid with peroxide of iron. Berzelius, not admitting the existence of any such acid as the ferro-cyanic, regards prussian blue as a compound of hydro-cyanate of protoxide of iron with peroxide of iron, in proportions admitting of some variation. (Ann. of Phil. N. S. i. 444.) Robiquet, on the other hand, considers it as a cyanide of iron, combined with a ferro-cyanate of the peroxide and with water. The subject, in its present state, appears to me very obscure, and I refer the reader, who is disposed to examine it, to the papers of Berzelius and Robiquet already quoted.

Atomic Constitution and Artificial Formation of Formic Acid.—

Vol. II. p. 256.

REDUCING the proportions obtained by Berzelius to atoms, we find that formic acid is constituted of

Carbon	. .	2 atoms	. .	12	. .	32.4
Oxygen	. .	3 ditto	. .	24	. .	64.8
Hydrogen	. .	1 ditto	. .	1	. .	2.8
				<hr/>		<hr/>
				37		100.

The equivalent thus deduced differs very little from that derivable from the composition of formate of lead, which Berzelius found to consist of 100 acid + 298.1 base. If these results are worthy of confidence, there is a material difference between the

constitution of formic and acetic acids, the latter of which contains 4 atoms of carbon + 3 of oxygen + 2 of hydrogen, and is represented by 50. The acid, to which the formic most nearly approaches, is the oxalic, from which it differs only in containing an atom of hydrogen in addition to the carbon and oxygen. Dobereiner has formed it artificially, by slightly heating bi-tartrate of potassa or tartaric acid with black oxide of manganese and water. A great quantity of carbonic acid escapes, and a sour colourless liquid distils, which is formic acid. (Ann. of Phil. N. S. iv. 310.)

ADDITIONS TO THE CHAPTER ON THE MORE COMPLEX
ANIMAL PRODUCTS.—PART I. CHAP. XXIII.

State of the Contents of the Stomach during Digestion.—
Vol. II. p. 268.

THE contents of the stomach, during the process of digestion, are almost always acid, but the nature of the acid has not been clearly ascertained. It is evidently, Dr. Prout observes, a volatile acid, because its effects on litmus paper disappear on drying. (Ann. of Phil. xiii. 271.)

The contents of the stomachs of animals feeding exclusively on vegetable food, even when about to pass the pylorus, and apparently fully digested, exhibit no traces of albumen. This change, Dr. Prout observes, requires the action of the pancreatic and biliary fluids, and is not distinctly visible till the food has passed some distance into the duodenum. Digestion, therefore, though begun in the stomach, is only imperfectly performed in that organ.

Account of Caseic Acid and Caseous Oxide, Substances produced by the Fermentation of Curd.—Vol. II. p. 276.

IN addition to the substances before found in cheese, Proust has discovered two new ones, *viz.* a combustible acid and a combustible oxide, both of which he believes to be the produce of the fermentation of the curd. They may be obtained as follows:—The curd of milk is to be kept several days under water, and then put into a bottle containing water enough to cover it a few inches, the mouth being closed by a small plate of glass. No gas is evolved; but acetic, phosphoric, and caseic acids are produced,

all saturated with ammonia, which is generated at the same time. The fluid may be withdrawn, and replaced by fresh water, when the same changes will go on as before. These washings, evaporated in a silver basin and left to stand a few days, solidify into a saline mass slightly transparent, and tasting strongly of cheese. The three salts already mentioned are to be dissolved by alcohol, and the solution boiled with carbonate of lead. The phosphoric acid, forming an insoluble salt, is thus separated; and the mixture of caseate and acetate of lead is to be decomposed by sulphuretted hydrogen. The two acids remaining in solution are separated from each other by distillation, the acetic only being volatile.

Caseic Acid is of the colour and consistence of sirup; reddens litmus paper; and has an acid bitter taste, mixed with that of cheese. It concretes, on standing, into a granular transparent mass like honey. It does not affect lime-water, muriate of tin, or acetate of lead. It precipitates the oxides of silver, gold, and mercury, but not the oxides of metals that more strongly attract oxygen. With infusion of galls, it produces a thick white precipitate. Nitric acid converts it into oxalic acid, forming at the same time a little benzoic acid, and some of the yellow bitter principle.

Caseate of ammonia has a sharp saline bitter taste, mixed with that of cheese, to which indeed it appears chiefly to communicate flavour. It always contains an excess of acid, and is not crystallizable.

The Caseous Oxide remains after the action of alcohol on the saline mass before described, constituting a bulky white powder. It is to be purified by washing with water till deprived of all cheesy taste; and afterwards by boiling in water, filtering, and evaporation, during which the oxide forms films on the surface, which are to be separated, washed, and dried. It is almost tasteless, soft to the touch, crumbles under the fingers, and when pressed hard has a peculiar greasy feel. It begins to dissolve in water at 140°. Hot alcohol dissolves very little, and it separates on cooling in crystalline grains. It is insoluble in ether, but disappears rapidly in liquid potassa.

Caseous oxide occurs frequently in cheese in detached points, and forms those small particles which affect the teeth like an earthy and dry substance. The oxide and caseate of ammonia together constitute from 30 to 35 per cent. of good cheese. (Quarterly Journ. vii. 391.)

New Chemical Researches on Eggs.—Vol. II. p. 277.

Eggs have lately been attentively examined by Dr. Prout, (Phil. Trans. 1822), in the course of an inquiry into the changes that occur during incubation. The specific gravity of new laid eggs was found to vary from 1.080 to 1.090. By long keeping, they become specifically lighter than water, in consequence of the substi-

tution of a quantity of air, for the water which escapes through their pores. They suffer also a great loss of weight, amounting on an average to little short of a grain per day. Of an egg weighing 1000 grains, the shell constitutes about 106 grains, the white 604, and the yolk 290, or thereabouts.

Eggs lose a little of their weight by being boiled, and the water becomes impregnated with about 0.3 grains of saline matter from an egg of common size. This saline fluid is found on evaporation to be strongly alkaline, and to contain also animal matter, sulphuric and phosphoric acids, chlorine, lime, magnesia, and carbonates of those earths, all which substances exist both in the white and the yolk.

The shell contains about 2 per cent. of animal matter, with 1 per cent. of phosphates of lime and magnesia, the rest being carbonate of lime with a little carbonate of magnesia. Vauquelin found, also, in the burnt shells, traces of iron and sulphur.

The yolk of the egg, besides the more common ingredients of animal fluids, contains a considerable portion of uncombined phosphorus; which, when the dried yolk is burnt, forms a glassy coating of phosphoric acid, that effectually defends the charcoal from combustion. In the white of egg, which, as has been already stated, consists chiefly of albumen, sulphur exists in a free state, and by combustion becomes, as Berzelius has remarked, changed into sulphuric acid. The yolk communicates to heated alcohol a deep yellow colour, and on cooling, crystals of a sebaceous matter are deposited, and a portion of a yellow semi-fluid oil. On distilling off the alcohol, the oil may be obtained separate. In one instance, the yolk, weighing 316.5 grains, contained 170.2 water, 55.3 albumen, and 91 yellow oil; but these proportions varied in different instances. The proportions of the saline matter, both of the white and yolk to each other, appear liable, also, to considerable variation.

Comparative Analysis of the Chyle of the Dog, when fed exclusively on Animal, and on Vegetable Food.—Vol. II. p. 278.

THE most recent examinations of the chyle are by Drs. Marcet and Prout, who compared the chyle from two dogs, the one exclusively fed on animal, the other on vegetable food. Their results are contained in the following Table. (Ann. of Phil. xv. 25.)

	Vegetable Food.	Animal Food.
Water	93.6	89.2
Fibrin	0.6	0.8
Incipient albumen?	4.6	4.7
Sugar of milk?	a trace	—
Oily matter	a trace	trace
Saline matters	0.8	0.7
	100.	100.

Properties of Pus, and its Discrimination from Mucus.—
Vol. II. p. 282.

Pus is the fluid secreted by an inflamed surface, generally towards the close of the inflammation. It is of a yellowish-white colour, and of the consistence of thick cream; has the sp. gr. 1.031 to 1.033; is insipid and inodorous when cold; and, when examined by the microscope, exhibits white globules, swimming in a transparent fluid. It produces no change on vegetable colours in its recent state, but becomes acid on exposure to the air.

Pus is not easily miscible with water, and when agitated with it, the pus sinks to the bottom on standing. Diluted sulphuric acid does not act upon it, but concentrated sulphuric, muriatic, and nitric acids dissolve it. Alkaline solutions form with it a whitish ropy fluid, which is precipitated on adding water. Pure ammonia changes it to a transparent jelly, and dissolves a considerable proportion of it.

Pus yields a white precipitate with nitrate of silver, and a still more copious and flaky one with nitrate and with bi-chloride of mercury. Its characters appear, however, to be liable to several modifications, which are described by Dr. Pearson in the *Philos. Trans.* for 1810. The criteria proposed for distinguishing pus from mucus, Dr. Pearson did not find at all satisfactory; but the following has since been proposed by Grasmeyer. Triturate the fluid to be tried with an equal quantity of warm water; then add to it an equal portion of a saturated solution of subcarbonate of potassa; and set the mixture aside. If it contain pus, a transparent jelly subsides in a few hours, but this does not happen if only mucus be present. (*Thomson's Chemistry*, iv. 584.)

*Chemical Changes, effected in the Kidneys.—*Vol. II. p. 288.

ACIDIFICATION, it has been justly observed by Berzelius, is the chief healthy office of the kidneys. It is in those organs, that the sulphur and phosphorus present in blood are converted into sulphuric and phosphoric acids, and that a new acid, the uric, is generated. In some diseases, this acidifying tendency is carried to excess, and nitric and oxalic acids are generated; the former of which probably converts a part of the uric acid into purpuric; and the latter, uniting with lime, composes oxalate of lime. In other cases, the acidifying process is suspended, and unchanged blood or albumen; neutral substances, as sugar or urea; and even alkalies, as ammonia, lime, or magnesia, are abundantly separated, the sulphur and phosphorus at the same time escaping unacidified. When acids are formed in excess, the urine is scanty and high coloured, and the character of the disease is inflammatory. When neutral or alkaline substances are redundant, the urine is pale and copi-

ous, and the disease is accompanied with irritation or debility. (See Prout on Calculus.)

*Nature of the Red Sand, voided from the Urinary Passages:—
Urate of Ammonia Calculus.—Vol. II. p. 291.*

THE *Red Sand*, voided occasionally in considerable quantity, and constituting one of the forms of the disease called *the gravel*, is uric acid very nearly pure. It is probably liberated from urate of ammonia by a free acid generated in the kidneys, just as it is precipitated by adding any acid to urine recently voided. The acid precipitating gravel in the kidneys may be either the phosphoric, nitric, or purpuric. (Prout, p. 127.)

The *Urate or Lithate of Ammonia Calculus* is generally of a clay colour, with a smooth and sometimes tuberculated surface. It is composed of concentric layers, and its fracture is very fine earthy, resembling that of compact lime-stone. It is small, and in its pure state, rather uncommon, but urate of ammonia often occurs with uric acid forming a mixed calculus.

In chemical characters, it closely resembles the uric species. Before the blow-pipe, however, it decrepitates strongly. It is much more soluble in water than uric acid calculus, and always emits a smell of ammonia with caustic potassa. It readily dissolves also in alkaline sub-carbonates, which the uric species does not. (Prout, p. 84.)

Ultimate Analysis of Wool and Silk.—Vol. II. p. 301.

Wool has not been so much the subject of experiment, as, from its great importance, it deserves. What is known respecting it may be found in Bancroft's and Berthollet's Treatises on Dyeing. When growing upon the sheep, it is enveloped in a soapy matter, from which it requires to be cleansed before it is manufactured.

Braconnot has shown, that, by the action of sulphuric acid, wool is converted into the peculiar substance called *leucine*. The ultimate analysis of wool has been performed by Dr. Ure, who finds it to consist of

Carbon	. . .	10 atoms	. .	60	. .	55.00
Oxygen	. . .	4 ditto	. .	32	. .	29.40
Hydrogen	. .	3 ditto	. .	3	. .	2.80
Azote	. . .	1 ditto	. .	14	. .	12.80
				<hr/>		<hr/>
				109		100.

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Silk, the production of various species of caterpillars, and used as the soft covering of the insect during its crýsalis state, is in fine threads, covered with a sort of varnish. This varnish is soluble in boiling water, but not in alcohol; it resembles gelatin in being precipitable by tan and muriate of tin, but differs from it in other respects. It may be separated also from silk by soap, and by soap leys. It amounts, according to Roard, to 23 per cent. of the weight of the silk. (Ann. de Chim. lxxv.) Raw silk, also, contains a portion of wax, which dissolves in boiling alcohol, and separates as the alcohol cools.

Dr. Ure submitted the bleached fibres of silk to decomposition by peroxide of copper, and obtained the following results. (Phil. Trans. 1822.)

Carbon	.	.	10 atoms	.	60	.	.	50.8
Oxygen	.	.	5 ditto	.	40	.	.	34.
Hydrogen	.	.	4 ditto	.	4	.	.	3.4
Nitrogen	.	.	1 ditto	.	14	.	.	11.8
					<hr/>			<hr/>
					118			100.

ADDITIONS TO PART II.

THIS PART EMBRACES DIRECTIONS FOR EXAMINING MINERAL
WATERS AND MINERAL BODIES IN GENERAL.

[In the corresponding portion of the new English edition (ninth), under the altered title of "Chemical Analysis," the following Chapter is given, which precedes the original chapters on the "Analysis of Mineral Waters" and the "Examination of Minerals" of the former Edition.—B.]

NEW CHAPTER.

ON THE ANALYSIS OF MIXED GASES.

HAVING already enumerated (See Body of the Work, to which this is a Supplement) the properties common to the whole class of gaseous bodies, and described the apparatus required for submitting them to experiment; and having also given the chemical history of each individual gas, it would be equally tedious and useless to enter, in this place, into minute details respecting them. Nor could it serve any useful purpose to frame rules for analyzing every possible mixture of gaseous substances; for, out of nearly thirty gases, the number of such combinations would be extremely numerous, and many of them are not at all likely to occur. The rules, too, themselves, would be unnecessary to those who are qualified to undertake researches into this difficult part of experimental chemistry. All, therefore, that I shall attempt, will be to lay down a few simple directions for discriminating the several gases, and for analyzing such mixtures of them, as are occasionally formed by chemical processes, or are presented to us by nature.

There are two fluids which are used to confine gases for the purpose of examination and analysis, viz. mercury and water. Upon the former, very few gases act sufficiently to interfere with its fitness for retaining them unaltered. Chlorine and nitrous acid gases are the principal exceptions to this remark; for they are both speedily condensed by mercury; and sulphuretted hydrogen acts also upon that metal, though not in the same degree. With the ex-

ception, however, of nitrous acid gas, those æriform substances that cannot be kept over mercury may, in general, be preserved over water, especially if its temperature be raised to 65° or 70° Fahr.; at least they may be kept long enough to enable us to examine their properties, and their proportions in any mixture.

The two following Tables exhibit a view of the different gases, and the fluids best adapted for preserving them.

I. Gases which are best confined by Mercury.

Oxides (supporters of Combustion).	Combustible Gases.	Acid Gases.
Protoxide of chlorine	Ammonia	Muriatic acid
Peroxide of ditto.	Cyanogen.	Hydriodic do.
		Sulphurous do.
		Fluoboric do.
		Fluosilicic do.
		Carbonic do.
		Chloro-carbonic do.

II. Gases confinable by Water.

Gases that support Combustion.	Combustible Gases.	Incombustible.
Oxygen	Hydrogen	Nitrogen
Chlorine	Carburetted hydrogen	Carbonic acid.
Nitrous oxide	Olefiant gas	
— gas.	Phosphuretted hydrogen	
	Biphosphuretted do.	
	Sulphuretted do.	
	Telluretted do.	
	Arsenuretted do.	
	Selenuretted do.	
	Carbonic oxide.	

Examination of Gases confinable by Mercury.

I. When we have a quantity of any unknown gas standing over mercury, it is desirable first to ascertain in what proportion it is capable of being absorbed by water. For this purpose a small quantity of water, not exceeding 1-80th or 1-100th of the volume of the gas, may be admitted to a portion of it contained in a graduated tube. If the whole gas rapidly disappear, and its place be filled with mercury, it must have consisted of one or more of the following gases:

Ammonia, of which 1 vol. water absorbs 670 vols.	
Fluoboric acid, —————	700
Fluosilicic, —————	260
Hydriodic, —————	+ 500
Muriatic, —————	480

Sulphurous acid, being soluble only to the extent of about 33 times the volume of the water, is not taken up with so much rapidity, or by so small a proportion of water as the other five gases. Protoxide and peroxide of chlorine are still less absorbable; for, of each of these, water condenses only about eight volumes.

II. To determine whether the gas has acid or alkaline properties, a small slip of litmus paper may be first introduced into it. If it be reddened, the gas must be acid; if not changed, a slip either of litmus paper reddened by vinegar, or of turmeric paper, may be passed up, when the alkaline nature of the gas will be indicated by the usual change of colour to blue or brown. Acid and alkaline gases cannot both exist together in the same mixture, as they immediately condense each other into a solid form.

III. *Ammonia*, when indicated by the colour tests, may either be pure, or may be mixed with cyanogen, or perhaps with one of the oxides of chlorine? (a) If pure, it will entirely disappear by contact with 1-100th its volume of water. (b) If any portion be left unabsorbed, let it be agitated with a little liquid potassa, and if an absorption now take place, pass up a small quantity of solution of per-sulphate of iron with an excess of acid. Cyanogen will be indicated by the blue colour of the liquid. (c) The oxides of chlorine will be distinguished by their greenish-yellow colour, by their smell, and by their power of supporting combustion, without exhibiting the characters belonging to oxygen, chlorine, or the oxides of nitrogen.

Acid Gases.

IV. Of the acid gases, there are four, which, when suffered to escape into the atmosphere, produce a *dense white smoke*, owing to their powerful attraction for aqueous vapour. These are the muriatic, fluoboric, fluosilicic, and hydriodic acids.

V. A property common to all the powerfully acid gases, *viz.* the fluoboric, fluosilicic, hydriodic, muriatic, and sulphurous, is, that they are absorbed by *fragments of borax*, which salt has no action on either of the oxides of chlorine, or on carbonic or chloro-carbonic acids.

(a) If the borax, after being thus exposed, be powdered and strongly heated with a little charcoal, and the product be then moistened with water, or with diluted muriatic acid, the presence of *sulphurous acid* will be indicated by a smell of sulphuretted hydrogen.

(b) If the gas, which has been absorbed by the borax, be *muriatic acid*, on dissolving the salt in water and adding nitrate of silver, a precipitate will appear, which will be soluble in liquid ammonia, and insoluble in diluted nitric acid. This precipitate, after being well washed, dried, and fused, will, for every 100 grains, indicate 24.5 grains of chlorine, equivalent to very nearly 25.1 grains, or 64 cubic inches of the acid gas.

VI. A test of the presence of *sulphurous acid*, which acts upon that gas, but not on the other acid gases, is the peroxide of lead.

According to Dr. Thomson, it may be employed to absorb sulphurous acid from the other acid gases.

VII. The mixture of acid gases which is likely most frequently to occur, is that of *muriatic* and *sulphurous acids*, or one of them, with *carbonic acid*.

(a) From a measured portion of a mixture of these three gases, contained in a graduated tube, the *muriatic acid gas* will be absorbed by $\frac{1}{30}$ th its bulk of water.

(b) From another portion of the mixture, contained in a similar tube, peroxide of lead will absorb the *sulphurous acid* only.

(c) From a third portion, both the *muriatic* and *sulphurous acids* will be absorbed by fragments of borax, leaving the *carbonic acid* separate.

The volume of the three gases, thus determined, ought, if the analysis be correct, to make up a sum total equal to that of the mixture.

VIII. *Hydriodic*, *fluoboric*, *fluosilicic*, and *chloro-carbonic acid gases* are of such rare occurrence, that it may be sufficient to point out a few tests by which they may be discriminated.

(a) If a little chlorine be passed into a gas containing *hydriodic acid*, a violet-coloured cloud will be immediately produced, the chlorine seizing the hydrogen of the acid gas, and detaching purple vapours of iodine.

(b) When borax has been made to absorb *hydriodic acid gas* without any admixture of *muriatic acid*, its solution in water precipitates nitrate of silver; but the precipitate is insoluble in ammonia, and by this property it may be separated from chloride of silver.

(c) A slip of white paper, introduced into a gas over mercury, betrays the presence of *fluoboric acid gas*, by being immediately blackened.

(d) *Fluosilicic acid gas* is manifested by its producing minute white flakes of silica, in a portion of water which has absorbed any considerable quantity of the gas.

(e) *Chloro-carbonic acid* is decomposed by contact with water; *muriatic acid* is formed and remains in solution. *Carbonic acid* is also produced, equal in volume to the original gas, and may be made apparent, by first saturating the *muriatic acid* with a little ammonia, and then adding lime-water, which will form a white precipitate.

Gases confinable by Water.

IX. All gases are more or less absorbable by water, but some of them are taken up to a much greater amount, and with much less agitation, than others. It affords, indeed, some insight into the nature of a gas, to ascertain the proportion in which it is capable of being absorbed by water. The water employed for this purpose should have been deprived, as completely as possible, of its air by long boiling, and should have been cooled out of contact

with atmospheric air. The best method of applying it, is by means of a caoutchouc bottle and tube, resembling that represented in plate ii. fig. 21: [See plates belonging to the body of the work.] but the tube, as well as the bottle, should be much larger than are commonly applied to eudiometrical purposes.

Water absorbs,

Twice its vol. of	{ Chlorine gas, Sulphuretted hydrogen, Selenuretted hydrogen.
An equal vol. of	{ Nitrous oxide, Carbonic acid.
One-eighth its vol. of	{ Olefiant gas, Phosphuretted hydrogen.
$\frac{1}{18}$ th to $\frac{1}{20}$ th its vol. of	{ Nitrous gas, Oxygen gas.
$\frac{1}{27}$ th to $\frac{1}{26}$ th its vol. of	{ Biphosphuretted hydrogen, Telluretted hydrogen.
$\frac{1}{30}$ th to $\frac{1}{24}$ th its vol. of	{ Nitrogen, Hydrogen, Carburetted hydrogen, Arsenuretted hydrogen.

It is necessary, however, to observe that considerable differences in the absorbability of gases are produced by their mixture with each other. The information, therefore, which can be thus obtained, is only of a very general kind, and must in no case supersede the application of other methods of analysis.

X. The effect of the watery solution of any gas upon the *colour tests* should next be examined. All the stronger acids, it has already been stated, redden litmus. The same effect is produced, though less readily and distinctly, by cyanogen, carbonic acid, sulphuretted hydrogen, and telluretted hydrogen. Chlorine destroys vegetable blues; and the oxides of chlorine first redden litmus, and then destroy its colour. The other gases, which are permanent over water, do not affect vegetable colours.

XI. When the quantity of a gas is sufficient to enable us to determine its *specific gravity*, we obtain a datum of great importance for determining its nature.

XII. Of the gases, which are capable of existing at common temperatures over water, two only are distinguished by being themselves *coloured*. Chlorine is yellowish-green, and nitrous acid gas of an orange-red; but the latter is so quickly absorbed by water, that its colour can only be seen, when first formed by the mixture of nitrous and oxygen gases.

XIII. The *odour* of gases discriminates several of them. Oxygen, hydrogen, nitrogen, and both the varieties of carburetted hydrogen, if pure, have little or no smell. All the rest have characteristic odours. That of chlorine is peculiar, and very suffocating;

that of nitrous gas can only be perceived in a state of mixture with the air already present in the nostrils, with which it forms nitrous acid. All the other compounds of hydrogen have powerful and generally disagreeable odours.

XIV. The gases, which are *absorbed by liquid potassa*, are cyanogen, chlorine and its oxides, carbonic acid, and sulphuretted, telluretted, and selenuretted hydrogen. Those acid gases, that are permanent only over mercury, are of course copiously soluble in liquid potassa, but they are not expelled again, like the gases which have been enumerated, by adding the stronger liquid acids.

XV. A leading distinction among gases, permanent over water, is into such as are capable of *supporting combustion* (that of a wax taper for example) and such as *extinguish flame*. One of the first experiments then, that should be tried on any unknown gas, is the effect of immersing a lighted taper in it. In oxygen gas, and in nitrous oxide, the taper will burn with great brilliancy; and if blown out, and again plunged into either of those gases, the ignited wick will be re-kindled with a slight explosion. The same effect is produced by the two oxides of chlorine. In chlorine, it burns a short time with a dense smoke, and is then extinguished. Nitrous gas does not support the flame of a taper, but sulphur and phosphorus continue to burn when introduced in a state of combustion into that gas.

Gases that support Combustion.

XVI. *Oxygen Gas* may be recognised in any mixture by the action of nitrous gas, which, when mingled with it, produces red fumes of nitrous acid, and a diminution of volume. With proper attention to the manner of making the mixture, and to other circumstances described vol. i. p. 308, [See body of the work], the proportion of oxygen may be thus determined. Oxygen may also be measured by combustion with hydrogen.

XVII. *Chlorine* is discoverable by its yellowish-green hue, its suffocating smell, and still more distinctly by its power of discharging vegetable colours.

(a) If chlorine be mingled with other gases, which are incapable of being absorbed by liquid potassa, its separation is very simple, and its quantity is determinable by the amount of the absorption produced by that liquid.

(b) Its proportion in more complicated mixtures may be ascertained by admitting, to a measured portion of the gas, an equal volume of olefiant gas. After standing a quarter of an hour completely excluded from the light, a diminution of volume will be perceived, the amount of which, divided by 2, shows very nearly the quantity of chlorine contained in the mixture.

XVIII. *Nitrous Oxide* supports the flame of a candle, and forms with hydrogen gas a detonating mixture; but nitrous oxide is not diminished in volume when mingled with nitrous gas, a property which distinguishes it from oxygen. From chlorine, it differs

in being colourless, and almost free from smell, and in being only about half as absorbable by water.

XIX. Nitrous Gas is diminished in volume, dense red fumes being at the same time produced, when it is mingled with oxygen gas or with atmospheric air. From the amount of its diminution under certain circumstances, its quantity may be estimated. [See body of the work, vol. i. p. 308.] Nitrous gas is distinguished, also, by the property of being absorbed by the solution of green sulphate of iron, and may, by means of that solution, be separated from several other gases.

XX. Incompatible Gases.—Of the gases that support combustion, oxygen and nitrous gas cannot exist together in the same mixture, since they mutually condense each other. So also do nitrous gas and chlorine, or its protoxide.

(a) *Chlorine* and *oxygen* gases are separable from each other by liquid potassa, which absorbs the chlorine only. In the same way, chlorine may be separated from nitrous oxide.

(b) *Oxygen* and *nitrous oxide* may be separated by a solution of nitrous gas in sulphate of iron; which condenses the oxygen only.

(c) *Nitrous gas* may be absorbed from a mixture with *nitrous oxide*, by solution of green sulphate of iron, which acts only on the former gas.

Examination of Combustible Gases.

XXI. Odour.—Some insight into the nature of these gases may be gained from their odour. Hydrogen and its compounds with carbon are, when pure, nearly free from odour. Sulphuretted hydrogen resembles the washings of a gun barrel; phosphuretted hydrogen has a peculiar odour, difficult to describe, but resembling that of onions; biphosphuretted hydrogen, a similar smell in a still greater degree; arsenuretted hydrogen, that of garlic; telluretted hydrogen resembles sulphuretted hydrogen; and selenuretted hydrogen has a most penetrating smell of horse-radish, and, even in very small quantity, excites a painful inflammation of the membrane of the nostrils.

XXII. Spontaneous Inflammability.—Biphosphuretted hydrogen is the only gas that takes fire spontaneously, when suffered to escape into the atmosphere.

XXIII. Action of pure alkaline solutions.—Sulphuretted, telluretted, and selenuretted hydrogen are the only species of inflammable gases that are rapidly absorbed by liquid potassa.

XXIV. Action of Chlorine.—Chlorine acts upon all the combustible gases, but with phenomena peculiar to each.

(a) Both varieties of *phosphuretted hydrogen* inflame spontaneously when brought into contact with chlorine, and, if in sufficient quantity, even detonate loudly.

(b) *Sulphuretted hydrogen* is immediately decomposed by chlorine, and sulphur is precipitated. One volume of the inflammable gas requires, for complete decomposition, one volume of chlorine.

(c) *Bicarburetted Hydrogen (olefiant gas)* is speedily condensed by chlorine into an oily-looking liquid with an ethereal smell, which floats on the surface of the water. One volume of olefiant gas condenses one volume of chlorine. Hence it is easy, by dividing the diminution of volume by 2, to estimate the amount of the former gas. The olefiant gas should be added to the chlorine in a graduated tube shaded from the light, and about a quarter of an hour should be allowed for the full effect to be produced, especially if the tube be of small diameter.

(d) *Hydrogen and carburetted hydrogen* are not acted upon by chlorine, provided the mixture be made and preserved in a tube from which all light, both direct and reflected, is carefully excluded. But the ordinary light of day, and still more the direct rays of the sun, falling on the mixture, occasions a speedy action of the gases on each other; and if the quantity be considerable, and the proportions properly adjusted, an explosion often ensues.

XXV. *Action of nitrous gas on inflammable gases.*—(a) Nitrous gas, beside being acted upon by oxygen, by chlorine and its protoxide, and by sulphurous acid gas, is also condensed by *biphosphuretted hydrogen* and by *sulphuretted hydrogen*. When mingled with the last mentioned gas, the decomposition is slow, sulphur is deposited, and ammonia and nitrous oxide are formed.

(b) On *hydrogen* and both the varieties of *carburetted hydrogen*, nitrous gas has no action at common temperatures. It may, therefore, be employed to determine the proportion of oxygen in a mixture of oxygen gas or atmospheric air with any of those three gases, according to the rules given in the body of the work, vol. i. p. 308.

XXVI. *Action of the solution of chloride (oxymuriate) of lime.* This solution, Mr. Dalton finds, absorbs phosphuretted hydrogen, converting it into phosphoric acid and water, but has no action on simple hydrogen. It is probably inefficient, also, on the two varieties of carburetted hydrogen.

XXVII. *Solutions of acetate of lead and nitrate of mercury.*—These solutions, even when heated to 120° Fahr. or upwards, absorb sulphuretted hydrogen, but do not affect the other combustible gases; nor do they, at that temperature, act on carbonic acid. A similar property belongs also to carbonate of lead precipitated by carbonate of ammonia from a cold solution of the acetate. In all these cases, a copious black precipitate is formed consisting of the sulphuret of lead or of mercury. The use of carbonate of lead in separating sulphuretted hydrogen from other gases, I find to be susceptible of great precision (Ann of Phil. xv. 35); and I have shown, that it is capable of detecting one part of sulphuretted hydrogen when mixed with 20,000 of any other gas. [See p. 67 of this Supplement].

Such are the principal agents required in operating on the inflammable gases. By using them in succession, considerable progress may be made towards the analysis of mixtures of these gases.

It may be proper to add a few rules for distinguishing the individual gases of this class, and estimating their quantities.

XXVIII. Telluretted, potassuretted, selenuretted, and arsenuretted hydrogen are of such rare occurrence, that it may be sufficient to enable the experimenter to recognise them, if a few of their leading characters are here enumerated.

(a) *Telluretted Hydrogen* is absorbed by liquid potassa, but not by acetate of lead. It is decomposed when mixed with chlorine, and if that gas be transmitted through the solution of telluretted hydrogen in liquid potassa, the liquid acquires the property of forming a white precipitate with alkaline carbonates, and a black one with hydro-sulphurets. (Children's Translation of Thenard, p. 25.)

(b) *Potassuretted Hydrogen* is instantly decomposed when brought into contact with water; hydrogen is liberated, and potassa formed.

(c) *Arsenuretted Hydrogen* has a nauseous smell, is sparingly soluble in water, is not absorbed by liquid potassa, but is instantly decomposed by chlorine, and condensed into a liquid, from which water, impregnated with sulphuretted hydrogen, throws down a yellow flaky precipitate. When mingled with gases that support combustion, it is discoverable by introducing a lighted taper into a tube filled with the gas, the sides of which will be immediately covered with a chestnut-brown hydruret of arsenic.

(d) *Selenuretted Hydrogen* may be recognised by its odour, (xxi.), by its absorbability by water, with which it affords a solution that in a few minutes becomes opalescent. reddish on the surface, and then deposits selenium. The watery solution reddens litmus, has an hepatic flavour, and gives a permanent brown stain to the skin; but by keeping is entirely decomposed.

XXIX. The mixtures, which may be expected most frequently to occur, of combustible gases with each other, are those of hydrogen, sulphuretted hydrogen, carburetted hydrogen, bicarburetted hydrogen (olefiant gas), and carbonic oxide, occasionally with small proportions of nitrogen or carbonic acid gas.

Of these gases, there are three, which may be removed from such a mixture by very simple processes, viz. sulphuretted hydrogen, carbonic acid, and olefiant gas.

(a) *Sulphuretted Hydrogen* may be absorbed, as already directed, by solution of acetate of lead, or by carbonate of lead fresh precipitated from the acetate, and diffused through a small quantity of water. Neither of these substances acts on carbonic acid or olefiant gas.

(b) After having thus removed the sulphuretted hydrogen, liquid potassa will absorb the carbonic acid, and will indicate its quantity by the amount of the absorption.

(c) Or we may act on one portion of the entire gas with potassa, and on another with acetate or carbonate of lead. The latter, affecting only the sulphuretted hydrogen, we may deduct the absorption it produces, from the total absorption by potassa, and the re-

mainder will show the proportion of carbonic acid. For example, if the absorption by potassa be 10 measures, and by lead 2, then $10 - 2 = 8$ shows the carbonic acid.

(d) *Olefiant Gas* mixed with one or more of the following gases, *viz.* hydrogen, carburetted hydrogen, carbonic oxide, or nitrogen, may be detected and estimated as follows. Into a graduated tube about $\frac{3}{16}$ ths of an inch in diameter, pass 20, 25, or 30 measures of chlorine, observing its quantity when actually in the tube, which is then to be shaded from the light by an opaque cover of tin or pasteboard. To the chlorine, pass up 50 measures of the gas under examination; let the mixture stand 10 or 15 minutes; and then gradually raise the cover till the surface of the water within the tube appears. Note the diminution, and divide its amount by 2, which will give the quantity of olefiant gas.

(e) Wash the residuum of the process (d) with liquid potassa. This will absorb any redundant chlorine. The mixture may now contain one or more of the following gases, *viz.* hydrogen, carburetted hydrogen, carbonic oxide, and nitrogen.

XXX. To analyze mixtures of *hydrogen, carburetted hydrogen, carbonic oxide, and nitrogen*, is a problem of considerable difficulty, since we are not acquainted with any agent, either liquid or æriform, that will condense one of those gases, leaving the others untouched. The only method of judging of the composition of such a mixture is, to fire a small quantity in a Volta's eudiometer over mercury, with oxygen gas, the degree of whose purity has been previously ascertained, and which must be employed in a proportion somewhat exceeding what is necessary for saturating the inflammable gas. Note the amount of the diminution after firing; then admit liquid potassa to the gas, and observe how much is absorbed; and ascertain the proportions of oxygen and nitrogen in the residue, by processes which will be presently described.

In estimating the composition of a mixed gas, from the phenomena and results of its combustion, the following Table will be found useful. Olefiant gas is included, though not strictly necessary, in order to render the view of these compounds more complete.

Table showing the Results of Firing the Combustible Gases with Oxygen.

Names of gases.	Sp. gr.	100 vols. require oxygen.	Total.	Diminished by firing.	Carbonic acid produced.
Olefiant gas9722	300	400	200 =	200
Carb. hydrogen5555	200	300	200 =	100
Hydrogen gas0690	50	150	150 =	0
Carbonic oxide9722	50	150	50 =	100

(a) If the gas under examination afford no carbonic acid by combustion with an excess of oxygen, it may then be either *hydrogen* only, or *hydrogen with a proportion of nitrogen*. In the first case, two measures of the gas will have condensed one of oxygen, making a diminution of three measures. In the second case, the diminution will be less than three measures.

(b) If the gas be found to have condensed twice its volume of oxygen, and to have given an equal volume of carbonic acid, it may be considered as pure *carburetted hydrogen gas*.

(c) If, while it affords an equal volume of carbonic acid, it has consumed only half its volume of oxygen, these are the characters of pure *carbonic oxide*.

(d) But if the gas under examination does not answer exactly in its characters to any one of those enumerated in the table, it may be inferred to be a mixture of two or more of the three last, with perhaps a proportion of nitrogen.

(e) The presence of nitrogen will be indicated by our finding, in the residuary gas after the action of liquid potassa, more nitrogen than can be traced to the oxygen gas employed in effecting the combustion. To decide this, add, to the residue, nearly twice its volume of hydrogen, and pass an electric spark through the mixture. If an explosion take place, we shall learn the amount of the residuary oxygen by dividing the diminution of volume on firing by 3, and the quotient, deducted from the whole residue, will show its proportion of nitrogen. If the quantity of nitrogen, thus determined, agree with that which formed part of the oxygen gas, no nitrogen is indicated in the inflammable gas; but if it exceed, the additional quantity must be referred to the combustible gas.

(f) If the mixture consist of hydrogen, carburetted hydrogen, and carbonic oxide, without any nitrogen, the proportions of each may be investigated as follows. Take the specific gravity of the gas, and then try what hypothetical proportions will most nearly agree with the characters of the mixture. An example will perhaps best explain the method of proceeding.

Let us take then the example of a gas of specific gravity 0.7012, 100 volumes of which have been found by experiment to afford by combustion 70 volumes of carbonic acid, the oxygen expended being 110 volumes, and the diminution on firing amounting to 140 volumes. Now, on inspecting the table, it must be obvious that these 70 volumes of carbonic acid cannot all have been produced from carburetted hydrogen, for in that case they would have required 140 volumes of oxygen, whereas only 110 volumes have been condensed. Part of the carbonic acid must therefore have resulted from a gas requiring less oxygen than is consumed by carburetted hydrogen; and the only gas answering to this description is carbonic oxide, the presence of which in the mixture may hence be safely inferred. The levity of the mixed gas indicates, also, that it contains hydrogen, which is also rendered probable by the amount of the diminution on firing. On trying various

proportions, the following will be found to afford the best explanation of the phenomena and products of combustion.

	Consume oxygen.	Give carbonic acid.	Condensed by firing.
40 vols. of carb. hydrogen . . .	80.	40.	80.
30 ——— carbonic oxide . . .	15.	30.	15.
30 ——— hydrogen . . .	15.	0.	45.
<hr/> 100	<hr/> 110.	<hr/> 70.	<hr/> 140.

The specific gravity of such a mixture ought to be

$$.9722 \times 4 = 3.8888$$

$$.0690 \times 3 = .2070$$

$$.9722 \times 3 = 2.9166$$

$$\hline 7.0124 \div 10 = 0.70124.$$

Such a coincidence of specific gravity with the results of combustion furnishes all the evidence, which is at present attainable, of the composition of mixtures of this kind; though it must be confessed that it is less complete than that which may be obtained in almost all other cases of gaseous mixture.

Analysis of Mixtures of Inflammable Gases, with Gases that support Combustion.

XXXI. No mixture, it must be obvious, can exist of gases that support combustion with gases that are spontaneously inflammable; for instance, of oxygen, nitrous oxide, or chlorine with phosphuretted hydrogen. Nor is sulphuretted hydrogen compatible with chlorine or with nitrous gas; nor chlorine with olefiant gas, or indeed with any of the varieties of carburetted hydrogen, unless light be carefully excluded from the mixture. But oxygen gas and atmospheric air may be, and the latter frequently is, mingled with hydrogen, carburetted hydrogen, olefiant gas, or carbonic oxide.

(a) A mixture of hydrogen and oxygen gases may be examined either by exploding the mixture, (rendering it combustible, if not already so, by adding more of the gas which may be deficient), or by the action of nitrous gas, or of a solution of nitrous gas in sulphate of iron.

(b) Atmospheric air mixed with hydrogen may be investigated by two separate experiments, the one for determining oxygen, the other nitrogen, by rules already given, vol. i. p. 140 of the body of the work.

(c) The presence of oxygen gas in olefiant gas, carburetted hydrogen, or carbonic oxide, may be easily ascertained by the effect of adding nitrous gas, which produces a dense red vapour and a diminution of volume; and the quantity of oxygen may be estimated in the manner described vol. i. page 308. [See the body of the work.] For detecting nitrogen, and ascertaining its quantity, rules have already been given, XXX. d.

Mixtures of Condensible Vapours with Gases.

XXXII. There are several vapours, which, at ordinary temperatures, are capable of existing as such, in a state of mixture with atmospherical air and other gases. In this state, it does not appear that the vapour is united with the gas by any affinity, but rather that, according to the theory of Mr. Dalton, it has a distinct and independent existence; for each vapour, when mingled with air or any other gas, at a certain temperature, has exactly the same tension or elasticity, which it would have *in vacuo* at the same temperature. It is easy then by inspecting tables, showing the force of the vapours of various fluids at different temperatures, to ascertain what proportion those vapours form of the whole weight of any gas. [See Tables at the end of this Supplement.] For example, at 60° Fahr. and 30 inches of the barometer, atmospheric air, fully charged with moisture, contains aqueous vapour, the force of which is equivalent to $\frac{1}{10}$ th that of the whole atmosphere. In the Appendix to this Supplement, rules are given for calculating what proportion of any mixture of gas and vapour, the vapour constitutes at a given temperature and pressure. With respect to the vapour of water, this is a correction which requires frequently to be made in calculating the weight of gases; and the same formula, which enables us to determine it in that case, is applicable to others, if for 0.620, (the specific gravity of steam), we substitute the specific gravity of any other gas or vapour, that may be the subject of investigation.

The vapours which may be occasionally mixed with permanent gases are,

(a) *Aqueous vapour, or the steam of water.*—This must necessarily exist in all gases confined by water, and its quantity will be proportionate to the temperature, as shown in the table of the force of vapour. The proportion which it constitutes of any gas, at a given temperature, may be determined by the rule given in the Appendix, referred to above.

Gases standing over mercury frequently also contain aqueous vapour. Its presence may be shown, either by surrounding with a freezing mixture a portion of the gas contained in a glass tube, when the inner surface of the tube will be obscured by a thin film of ice; or it may be discovered by a few bubbles of fluoboric gas, which occasion a dense white cloud. From gases confined over mercury, aqueous vapour may be removed, by bringing into contact with them chloride of calcium, recently cooled from a state of fusion.

(b). *Nitrous acid vapour.*—This is sufficiently distinguishable by its red colour, and its odour of nitrous acid. It is incompatible with sulphuretted, phosphuretted, telluretted, or arsenuretted hydrogen, with ammonia, with sulphurous acid when water is present, and probably with hydriodic acid.

(c) *The vapour of alcohol* may be known by its odour, but it

does not, at common temperatures, form a combustible mixture with atmospheric air or oxygen gas.

(d) *The vapour of ether* composes with oxygen gas an inflammable mixture which detonates violently.

All the three foregoing vapours are separated from permanent gases by passing the mixture through water, but ether less readily than the others.

(e) *The vapour of naphtha* is distinguishable by its peculiar smell. At common temperatures, it does not form a combustible mixture with oxygen. It has so little affinity for water, that a gas, with which it is mingled, may be several times passed through water, and even kept over that fluid without being deprived of it. (Saussure, Ann. of Phil. x. 120.)

(f) The vapour of *sulphuret of carbon* may be known by its smell; and by the other properties belonging to that substance, described vol. i. p. 296 of the body of the work.

There are various other fluids which yield vapours capable of forming permanent mixtures with the gases; but they are not likely to become subjects of examination, and in general they are sufficiently discriminated by the characters of smell or colour.

TABLE,

Referring to the Methods of detecting the different Gases, and analyzing Mixtures of them with each other.

N. B. The numerals, unless otherwise expressed, refer to the foregoing paragraphs.

Air, atmospheric. (See the Index to the body of the work, article Eudiometer.) Mixed with combustible gases, XXXI.

Ammonia. Absorption by water; I. Separation from other gases, III.

Bicarburetted hydrogen. See *hydrogen, bicarburetted*.

Biphosphuretted hydrogen. See *hydrogen, biphosphuretted*.

Borax. Gases absorbed by, V.

Carbonic acid. Separation from muriatic and sulphurous acid gases, VII. From sulphuretted hydrogen, &c. XXIX. a, b, c.

Carbonic oxide. Characters, and method of estimating its quantity, XXX. c.

Carburetted hydrogen. See *hydrogen carburetted*.

Chlorine. Tests of, XVII. a. Separation from other gases, b. From oxygen gas, XX. a. Action on combustible gases, XXIV.

Chlorine, protoxide of, I. Characters, III. c.

———— peroxide of, I. Characters, III. c.

Chloro-carbonic acid, VIII. e.

Colours of gases, III. c. XII.

Combustible gases, XXI. Mixtures with supporters of combustion, XXXI.

Combustion, gases that support, XV. XVI. &c.

Cyanogen. Tests of, III. b.

Fluoboric acid gas. Absorption by water, I. Tests of, VIII. *c.*
Fluosilicic acid gas. Absorption by water, I. Tests of, VIII. *d.*
Gases, acid, II. IV. Fuming. IV.

- absorption by water, IX.
- alkaline, II.
- coloured, XII.
- combustible, XXI. XXX.
- that support combustion, XV. XVI.
- incompatible, II. XX. XXXI. XXXII. *b.*
- odour of, XIII. XXI.

Gravity, specific, of gases, XI. Its coincidence with analytic results, XXX. *e.*

Hydriodic acid gas. Absorption, I. Tests of, VIII. *a, b.*

Hydrogen gas. Characters, XXX. *a.* How estimated when mixed with other combustible gases, XXX.

Hydrogen, arsenuretted. Odour, XXI. Characters, XXVIII. *c.*

Hydrogen, bicarburetted, (olefant gas.) Action of chlorine, XXIV. *c.* Separation from other gases, XXIX. *d.*

Hydrogen, biphosphuretted, XXIV. a.

— carburetted. Action of chlorine, XXIV. *d.* How separated from other gases, XXX. Characters, XXX. *b.*

Hydrogen, phosphuretted, (phosphoric gas) XXIV. a.

— potassuretted. Tests of, XXVIII. *b.*

— selenuretted. Odour, XXI. Characters, XXVIII. *d.*

Hydrogen, sulphuretted. Odour, XXI. Action of chlorine, XXIV. *b.* Absorbed by hot solutions of lead and mercury, XXVII. XXIX. *a.*

Hydrogen, telluretted. Odour, XXI. Characters, XXVIII. *a.*

Litmus. Gases that redden it, X.

Muriatic acid gas. Absorption by water, I. By borax, V. *b.* Analysis of mixtures of, VII.

Nitrogen, with oxygen gas. (See air, atmospheric.) Analysis of mixtures of with combustible gases, XXX. *d.*

Nitrous acid vapour, XXXII. b.

Nitrous gas. Tests of, XIX. Action on combustible gases, XXV. Separation from oxygen gas, XX. *c.*

Nitrous oxide. Tests of, XVIII. Separation from oxygen gas, XX. *b.*

Odour of gases, XIII. XXI.

Olefant gas. See *Hydrogen, bicarburetted.*

Oxygen gas. Tests of, XVI. Separation from chlorine, XX. *a;* from nitrous oxide, XX. *b;* from nitrous gas, XX. *c;* from combustible gases, XXV. *c;* XXXI. *d.*

Phosgene. See *Chloro-carbonic acid gas.*

Phosphuretted hydrogen. See *hydrogen.*

Potassa, liquid, gases absorbable by, XIV. XXIII.

Sulphuretted hydrogen. See *hydrogen, sulphuretted.*

Sulphurous acid. Absorption by water, I.; by borax, V. *a;* by

peroxide of lead, VI. Separation from muriatic acid gas, VII. *b*;
from carbonic acid, VII. *c*.

Telluretted hydrogen. See *hydrogen, telluretted*.

Vapours mixed with gases, XXXII.

Water. Action on gases, I. IX. Steam of, in gases, XXXII. *a*.

ADDITIONS TO THE CHAPTER ON THE ANALYSIS OF MINERAL WATERS.—PART II. CHAP. I.

Uses of Lime-water for Detecting Super-carbonate of Lime, or Magnesia.—Vol. II. p. 314.

WHEN lime-water is added to a water containing carbonate of lime, dissolved by an excess of carbonic acid, that excess unites with the lime, and forms an insoluble precipitate. In this case, in addition to the carbonate of lime, which before existed in the water, a fresh portion of carbonate is formed, and both are precipitated together.

When neither uncombined carbonic acid, alkaline or earthy carbonates, alumina, nor oxide of iron, exist in a mineral water, lime-water is one of the best precipitants of magnesia. It is necessary, however, in order to obtain the magnesia, to concentrate the water by evaporation. Less than the twelfth part of a grain of magnesia in a wine pint of water, Mr. Phillips finds may be shown to exist by adding lime-water. (*Ann. of Phil. N. S. i. 309.*)

Application of Gold Leaf as a Test for the Discovery of small Quantities of Salts, containing Nitric Acid.—Vol. II. p. 314.

A BEAUTIFUL application of *gold leaf* as a test of the presence of small quantities of salts containing nitric acid, has been contrived by Dr. Wollaston. Let the water, suspected to contain any nitrate, be concentrated by evaporation; then add a little sulphuric acid to the heated water, with a small quantity of muriate of soda, unless the water already contain some muriate, when the last mentioned addition is unnecessary. Immerse a little gold leaf in the mixture, and boil it. If any nitrate be present, the gold leaf will be immediately dissolved, and a smell of aqua regia will generally be perceived. (*Dr. Marcet on Sea Water, Phil. Trans. 1822, p. 452.*)

Method of Applying Solutions of Silver as Tests of Chlorine, when in Combination with Oxides.—Vol. II. p. 316.

WHEN solutions of silver are added to compounds of chlorine with oxides, for example to chloride of lime, (oxide of calcium), no escape of oxygen gas takes place, although the silver cannot unite with chlorine without abandoning its oxygen. This oxygen, detached from the silver, must necessarily unite with the chlorine, and form chloric acid, which constitutes with silver a soluble compound. It is necessary, then, after adding nitrate of silver to solution of chloride of lime till no farther precipitate ensues, to decant the clear liquor, to evaporate it to dryness, and heat the residue. Oxygen gas will be disengaged, and, to the residuum, water acidulated with nitric acid may be added, which will leave the chloride of silver. This process is always necessary when the base of any chloride, which we wish to decompose by nitrate of silver, is a metallic oxide. (Ann. de Chim. et Phys. xi. 108.)

Caution to be observed when Sulphuric Acid is precipitated from the Weaker Bases by a Barytic Salt:—Application of Acetate of Baryta in obtaining the Bases of all the Sulphates existing in any Solution.—Vol. II. p. 317.

It has been remarked by Berzelius, that, when sulphuric acid is precipitated from some of the weaker bases by a barytic salt, the precipitated sulphate of baryta is combined with a portion of those bases. Thus when sulphate of iron or copper is decomposed by muriate of baryta, the sulphate of baryta, when dried and calcined, assumes a reddish colour in the first case, or a yellowish-green in the second. In order, therefore, to determine with precision the quantity of sulphuric acid, it is necessary to remove the excess of oxide by some acid in which it is soluble. (Ann. de Chim. et Phys. xiv. 376.)

By the cautious addition of acetate of baryta, as long as it occasions any precipitate, all the sulphates existing in any solution are decomposed, and their bases are obtained united with acetic acid. By evaporating the liquid to dryness, and calcining the residuum, the acetic acid is destroyed, and the bases of these salts may be obtained separate, or combined only with carbonic acid, and in this state may be recognised by properties which are more characteristic than those belonging to them in a state of more energetic combination. In this way the alkaline bases may be obtained separately from the earthy ones; for the mere addition of water to the incinerated mass takes up the former, and leaves the latter.

ADDITIONS TO THE CHAPTER ON THE EXAMINATION
OF MINERALS.—PART II. CHAP. II.

Additional Methods of Separating Lime from Magnesia.—
Vol. II. p. 338.

MR. PHILLIPS recommends the following plan of separating lime and magnesia from each other. To the muriatic or nitric solution of the two earths, add sulphate of ammonia in sufficient quantity; evaporate the mixture gradually to dryness; and then heat it to redness, till it ceases to lose weight by the volatilization of the muriate or nitrate of ammonia formed. Note the weight of the mixed salt, reduce it to powder, and wash it with a cold saturated solution of sulphate of lime, till all the sulphate of magnesia appears to be dissolved; dry the sulphate of lime left; and by deducting its weight from that of the mixed sulphates, the quantity of sulphate of magnesia dissolved will appear. (Quart. Journ. vi. 316.) This method, which it appears had been practised also by Mr. Cooper, has been shown by the latter to be susceptible of great precision. (Quart. Journ. vii. 392.)

Mr. Daubeny, in an elaborate memoir on the methods of separating lime from magnesia, (Edinburgh Philosophical Journal, vii. 108.), proposes the following modification of the process which has been just described. Dissolve a given portion of the earth under examination in nitric acid, thus separating the silica, and most of the peroxide of iron, from the lime, magnesia, alumina, protoxide of iron, &c. Evaporate the solution, and drive off the nitric acid by heat, thus converting the iron into a peroxide. Weigh the residuum after calcination, and treat it with distilled vinegar or diluted acetic acid, which will take up only the lime and magnesia. Subtract the weight of the undissolved portion from that of the residuum after calcination, thus ascertaining the joint weight of the dissolved lime and magnesia; then decompose the acetates by sulphate of ammonia; evaporate the solution nearly to dryness, and separate the sulphate of magnesia from the sulphate of lime, by washing with water already saturated with sulphate of lime. Expose the sulphate of lime to a red heat, and ascertain its weight, from which the amount of the lime originally present may be readily deduced. We may then infer the weight of the magnesia from the difference between the amount of the lime, and that of the whole which the vinegar was found to have dissolved; or, if we wish to verify the result, it may be done by precipitating the magnesia by an alkali, or still better by converting it into triple phosphate. The quantity of sulphate of lime, present in the

water used for washing off the sulphate of magnesia, may be estimated and allowed for.

Or we may content ourselves by dissolving the lime and magnesia in muriatic acid; decomposing the solution by sulphate of ammonia; and after suffering the sulphate of lime to subside, decanting off the supernatant liquor, and throwing down the magnesia from the latter by carbonate of ammonia and phosphate of soda.

Additional Methods of Separating Iron from Manganese.—
Vol. II. p. 342.

SOME other methods of separating iron and manganese, in addition to that of Mr. Hatchett, have been described by Mr. Faraday in the sixth volume of the Quarterly Journal, p. 357. One of the most easy and simple seems to be, to throw down the oxides (the iron being peroxidized) together from their solution; to wash them by decantation; and to digest them in muriate of ammonia with a little sugar. The manganese, both protoxide and peroxide, will be dissolved, and the oxide of iron will remain.

Of these methods of separating iron and manganese, it is probable that Mr. Herschell was not aware, when (in a paper published in the Annals of Philosophy, N. S. iii. 95) he condemned as ineffectual all methods antecedent to the following, which he has himself proposed. The solution containing iron is to be brought to the maximum of oxidation, capable of being communicated by boiling with nitric acid. It is then to be just neutralized, *while in a state of ebullition*, by carbonate of ammonia. The whole of the iron to the last atom is precipitated, and the whole of the other metals present (supposed to be manganese, cerium, nickel, and cobalt) remains in solution. To insure success, it is necessary that no oxide of manganese or cerium, above the first degree of oxidation, should be present; otherwise it will fall down along with the iron. In performing the process, the metallic solution should not be too concentrated, and must be agitated the whole time, especially towards the end; and when the tests of alkalies are feebly affected, the ammoniacal carbonate must be added slowly and in a diluted state. The precipitation turns on a peculiarity in the peroxide of iron, by virtue of which it is incapable of existing in a neutral solution at a boiling temperature. It may be made, Mr. Herschell finds, the principle of a method of detecting the minutest quantity of other metals in union with iron, for example, of nickel, titanium, and manganese, but not of uranium.

Laugier's Method of Separating Nickel from Cobalt.—
Vol. II. p. 343.

LAUGIER has proposed a method of separating nickel from cobalt, founded on the solubility of the triple oxalate of ammonia and cobalt in water. The mixed oxalates of nickel and cobalt, precipitated by an alkaline oxalate, are to be placed in diluted ammonia, which dissolves both. The solution being exposed to the air, in order that the excess of ammonia may escape, the salt of nickel precipitates, while that of cobalt remains in solution.

Easy Method of detecting Fixed Alkalies in Minerals.—
Vol. II. p. 345.

IN certain minerals that gelatinate, when pulverized and exposed to the action of muriatic acid, Dr. Wollaston has pointed out an easy method of detecting alkalies. Expose the gelatinous mass in a watch-glass to a temperature not exceeding that of boiling water, until perfectly dry. In this state, if potassa or soda be present, small cubic crystals are generally discoverable with the assistance of a lens. In this way, Dr. Clarke was enabled to discover potassa in Gehlenite. (Ann. of Phil. xiv. 450.)

*Application of Nitrate of Lead to the Analysis of Stones, containing Silicated Alkali.—*Vol. II. p. 346.

BERARD has found, that nitrate of lead may be advantageously employed in the analysis of stones that contain silicated alkali. One part of the stone very finely powdered is to be intimately mixed with two parts of finely powdered nitrate, and one of carbonate, of lead. The whole is to be put into a platina crucible, which is to be placed in another crucible, and covered with a lid. A red heat is to be applied for a quarter of an hour. The fusion takes place without effervescence, and a yellowish or brownish mass is found in fusion on removing the cover. This is to be poured into water, the coldness of which causes it to split into small fragments that are easily attacked by acids, of which nitric acid is the one best adapted to the purpose. With this acid, it is to be boiled, and occasionally stirred and broken down. The silex remains in a viscid state. The oxide of lead is precipitated by sulphuric acid, added till water saturated with sulphuretted hydrogen causes no change. The liquid is boiled with carbonate of

ammonia, and the precipitate thus formed analyzed by common methods. Lastly, the liquid is evaporated to dryness; the salts calcined in a platinum crucible; and the residuum collected and weighed. This residue contains the alkali originally present in the mineral in the state of a sulphate, and almost always sulphate of magnesia. It may be analyzed by processes that have been already described, [See body of the work], or by others contrived by Berthier, and detailed in his paper. (*Ann. de Chim. et de Phys.* xvii. 28; or *Quarterly Journ.* xii. 169.)

ADDITIONS TO PART III.

THIS PART COMPRISES THE APPLICATION OF CHEMICAL TESTS
AND RE-AGENTS TO VARIOUS USEFUL PURPOSES.

ADDITIONS TO THE CHAPTER ON THE METHOD OF DETECTING POISONS.—PART III. CHAP. I.

Additional Methods of detecting Arsenic.—Vol. II. p. 361.

DR. PARIS conducts the trial in the following manner: drop the suspected fluid on a piece of white paper, making with it a broad line; along this line a stick of lunar caustic is to be slowly drawn several times successively, when a streak will appear of the colour resembling that known by the name of *Indian yellow*. This is equally produced by arsenic and by an alkaline phosphate, but the one from arsenic is rough, curdy, and flocculent, like that from a crayon; that from a phosphate is homogeneous and uniform, resembling a water-colour laid smoothly on with a brush. But a more important and distinctive peculiarity soon succeeds; for in less than two minutes the phosphoric yellow fades into a *sad green*, and becomes gradually darker, and ultimately quite black, while on the other hand the arsenic yellow continues permanent, or nearly so, for some time, and then becomes brown. In performing this experiment, the sunshine should be avoided, or the change of colour will take place too rapidly. (Ann. of Phil. x. 60.) The author of the London Dispensatory adds, that the test is improved by brushing the streak lightly over with liquid ammonia immediately after the application of the caustic, when, if arsenic be present, a bright queen's yellow is produced, which remains permanent for nearly an hour; but that when lunar caustic produces a *white* yellow before the ammonia is applied, we may infer the presence of some alkaline phosphate rather than of arsenic.

Mr. Smithson proposes to fuse any powder suspected to contain arsenic with nitre; this produces arseniate of potassa, of which the solution affords a brick-red precipitate with nitrate of silver. In cases where any sensible portion of the alkali of the nitre has been set free, it must be saturated with acetous acid, and the sa-

line mixture dried and re-dissolved in water. So small is the quantity of arsenic required for this mode of trial, that a drop of solution of oxide of arsenic in water (which at 54° Fahr. may be estimated to contain $\frac{1}{10}$ th its weight of the oxide), mixed with a little nitrate of potassa, and fused in a platinum spoon, affords a very sensible quantity of arseniate of silver. (Ann. of Phil. N. S. iv. 127.)

Dr. Cooper, President of Columbia College, finds a solution of chromate of potassa to be one of the best tests of arsenic. One drop is turned green by the fourth of a grain of arsenic, by two or three drops of Fowler's mineral solution, or any other arsenite of potassa. The arsenious acid takes oxygen from the chromic, which is converted into oxide of chrome. To exhibit the effect, take five watch glasses; put on one, two or three drops of a watery solution of white arsenic; on the second, as much arsenite of potassa; on the third, one-fourth of a grain of white arsenic in substance; on the fourth, two or three drops of solution of corrosive sublimate; on the fifth, two or three drops of a solution of copper. Add to each, three or four drops of a solution of chromate of potassa. In half an hour a bright clear grass-green colour will appear in numbers 1, 2, 3, unchangeable by ammonia; number 4 will instantly exhibit an orange precipitate; and number 5, a green, which a drop of ammonia will instantly change to blue. (Silliman's American Journal, iii.)

Additional Method of detecting Mercury.—Vol. II. p. 363.

MR. SMITHSON remarks, that all the oxides and saline compounds of mercury, if laid in a drop of marine acid on gold, with a bit of tin, quickly amalgamate the gold. In this way, a very minute quantity of corrosive sublimate, or a drop of its solution may be tried, and no addition of muriatic acid is then required. Quantities of mercury may thus be rendered evident, which could not be so by any other means. Even the mercury of cinnabar may be exhibited; but it must previously be boiled with a little sulphuric acid in a platinum spoon, to convert it into sulphate. An exceedingly minute quantity of metallic mercury in any powder may be discovered by placing it in nitric acid on gold, drying, and adding muriatic acid and tin.

New Test for the Discovery of Copper.—Vol. II. p. 364.

It into a newly prepared tincture of guaiacum wood, we drop a concentrated solution of a salt of copper, the mixture instantly as-

F f (S.)

sumes a blue colour. This effect does not take place when the solution is very weak, for example, when there is not above half a grain of the salt to an ounce of water; but then, by the addition of a few drops of prussic acid, the blue colour is instantly developed of great purity and intensity. This colour is not permanent, but soon passes to a green, and at length totally disappears. For want of prussic acid, distilled laurel water may be employed. The test produces its effect, even when the proportion of the salt of copper to the water does not exceed 1-45000th. In this minute proportion, no other test, whether the prussiate of potassa, soda, or ammonia, gives the least indication of copper. (Quart. Journ. x. 182.)

ADDITIONS TO THE CHAPTER ON THE RULES FOR ASCERTAINING THE PURITY OF CHEMICAL PREPARATIONS, EMPLOYED FOR THE PURPOSES OF MEDICINE, AND FOR OTHER USES.—PART III. CHAP. II.

Method of discovering Tartrate of Lime in Bi-tartrate of Potassa, (Cream of Tartar).—Vol. II. p. 372.

BI-TARTRATE of potassa frequently contains tartrate of lime. This may be discovered by burning a portion so as to destroy the acid; washing off by water the carbonate of potassa which is formed; and then acting on the residue with diluted muriatic acid. This dissolves the carbonate of lime, if any be present; and oxalate of ammonia, added to the solution, precipitates oxalate of lime.

Indications of the Presence of Triple Sulphate of Magnesia-and-Potassa in Epsom Salt.—Vol. II. p. 373.

MR. BRANDE has sometimes found, amongst Epsom salt, a very considerable proportion of the triple sulphate of magnesia-and-potassa. (Manual, Vol. i. p. 599.) It may be known by its sparing solubility, and by the rhomboidal shape of its crystals; by occasioning a gritty sensation in the mouth; and by being less bitter than the magnesian sulphate.

Method of Detecting Adulterations of Olive Oil with cheaper Oils.—Vol. II. p. 379.

OLIVE oil is sometimes adulterated with the cheaper oils obtained from grains and seeds. The acid pernitrate of mercury, (prepared by dissolving, in the cold, six parts of mercury in seven and a half of nitric acid, sp. gr. 1.36, or thereabouts), has the property of solidifying or congealing, in a few hours, genuine oil of olives; while it leaves the oils of grains almost entirely liquid, or at most produces a precipitate from them more or less sparingly, according to the proportions of oils that may be mixed together. Eight parts of pernitrate are sufficient to congeal 92 parts of pure olive oil. Mixtures of the genuine oil with cheaper oils exhibit only a slow and partial coagulation. One-third of oil of grains is sufficient to prevent the mixture from solidifying. (Ann. de. Chim. et de Phys. xii. 58).



ADDITIONS

TO THE APPENDIX.

CORRECTIONS FOR MOISTURE IN GASES.

A CORRECTION, which it is often necessary to make in taking the weight of gases, is for the quantity of aqueous vapour diffused through them. It is obvious, that all gases, which are specifically heavier than aqueous vapour, must have their specific gravity diminished by admixture with steam; and, on the contrary, all gases that are specifically lighter than steam must have their specific gravity increased by that admixture. For the following formulæ, I am indebted to Mr. Dalton, who has obligingly stated them at my request.

“At ordinary temperatures, the tension or elasticity of aqueous vapour varies from $\frac{1}{100}$ to $\frac{1}{10}$ of the whole atmospheric pressure; in the present case, it is supposed to be a given quantity. The specific gravity of pure steam compared with that of common air, under like circumstances of temperature and pressure, is, according to Gay-Lussac, as 0.620 to 1.

Let a = weight of 100 cubic inches of dry common air, at the pressure 30 inches and temperature 60° Fahr.; p = any variable pressure of atmospheric air; and f = pressure or tension of vapour in any moist gas. Then the following formulæ will be found useful in calculating the volumes, weights, and specific gravities of dry and moist gases; putting M for the volume of moist gas; D for that of dry gas; and V for that of vapour, all of the same pressure and temperature.

$$1. M = D + V.$$

$$2. \frac{p-f}{p} M = D.$$

$$3. \frac{p-f}{p} M = V.$$

$$4. M = \frac{pD}{p-f} = \frac{pV}{f}$$

If we wish to infer the specific gravity of any dry gas from the observed specific gravity or weight of the same mixed with vapour, it will be convenient to expound p by that particular value which corresponds with a , namely 30 inches of mercury; and let

s = the specific gravity of the dry gas, and w = the observed weight of 100 cubic inches of the moist gas.

Then we shall have the following, viz.:

$$5. \frac{30-f}{30} \cdot s a + \frac{f}{p} \times .620 a = w.$$

$$6. s = \frac{30}{30-f a} \left(w - \frac{f}{p} \times .620 a. \right)$$

EXEMPLIFICATIONS.

1. 98 vol. dry air + 2 vol. vapour = 100 vol. of moist air.

2. Given $p = 30$, $f = .5$, and $M = 100$.

Then $\frac{p-f}{p} M = D$, the dry air, = $98\frac{1}{3}$.

3. And $\frac{f}{p} M = V$, the vapour, = $1\frac{2}{3}$.

4. Given $D = 100$, $p = 30$, $f = .4$.

Then $\frac{30 \times 100}{29.6} = 101.35$, the moist air.

Given $V^* = 2$, $p = 30$, $f = .3$.

Then $\frac{30 \times 2}{.3} = 200$, the moist air.

5. Let $f = .5$, $s = 1.111$, $a = 30.5$, $p = 29.5$.

Then $\frac{30-.5}{30} 1.111 \times 30.5 + \frac{.5}{29.5} \times .62 \times 30.5 = 33.64 = w$, which gives the specific gravity 1.103.

6. Let f , a , and p as above, and $w = 2.5$, corresponding to sp. gr. 0.8197.

Then $s = \frac{30}{29.5 \times 30.5} \left(2.5 - \frac{.5}{29.5} \times .62 \times 30.5 \right) = .07266$.

The above formulæ apply equally well if V be a permanent gas, or any other vapour beside that of water, the specific gravity of the gas or vapour being substituted instead of .620, that of steam."

* It is easy to see that V , in this and the other cases, mostly will denote a virtual volume only; or such as would result, if the vapour were condensable like a gas, without being convertible into a liquid.

Elasticity of Aqueous Vapour below 32° according to Dalton.

Temperature.	Force of vap. in inches of mercury.	Temperature.	Force of vap. in inches of mercury.	Temperature.	Force of vap. in inches of mercury.	Temperature.	Force of vap. in inches of mercury.
-40°	0.013	5°	0.076	14°	0.104	23°	0.144
-30	0.020	6	0.079	15	0.108	24	0.150
-20	0.030	7	0.082	16	0.112	25	0.156
-10	0.043	8	0.085	17	0.116	26	0.162
0	0.064	9	0.087	18	0.120	27	0.168
1	0.066	10	0.090	19	0.124	28	0.174
2	0.068	11	0.093	20	0.129	29	0.180
3	0.071	12	0.096	21	0.134	30	0.186
4	0.074	13	0.100	22	0.139	31	0.193

Table of the Force of Aqueous Vapour above 32° Fahrenheit.

(From Dr. Thomson's Chemistry, 6th edition, i. 61.)*

Temperature.	Force of vapour in inches of mercury.				Temperature.	Force of vapour in inches of mercury.			
	Robison.	Dalton.	Ure.	Southern.		Robison.	Dalton.	Ure.	Southern.
32°	0.0	0.200	0.200	0.16	56°		0.458		
33		0.207			57		0.474		
34		0.214			58		0.490		
35		0.221			59		0.507		
36		0.229			60	0.35	0.524	0.516	
37		0.237			61		0.542		
38		0.245			62		0.560		0.52
39		0.254			63		0.578		
40	0.1	0.265	0.250		64		0.597		
41		0.273			65		0.616	0.630	
42		0.283		0.23	66		0.635		
43		0.294			67		0.655		
44		0.305			68		0.676		
45		0.316			69		0.698		
46		0.328			70	0.55	0.721	0.726	
47		0.339			71		0.745		
48		0.351			72		0.770		0.73
49		0.363			73		0.796		
50	0.2	0.375	0.360		74		0.823		
51		0.388			75		0.851	0.860	
52		0.401		0.35	76		0.880		
53		0.415			77		0.910		
54		0.429			78		0.940		
55		0.443	0.416		79		0.971		

* A Table for practical use is given by Mr. Philip Taylor, Phil. Mag. lx. 452.

TABLE CONTINUED.

Temperature.	Force of vapour in inches of mercury.				Temperature.	Force of vapour in inches of mercury.			
	Robison.	Dalton.	Ure.	Southern.		Robison.	Dalton.	Ure.	Southern.
80°	0.82	1.00	1.010		128°		4.11		
81		1.04			129		4.22		
82		1.07		1.02	130	3.95	4.34	4.366	
83		1.10			131		4.47		
84		1.14			132		4.60		4.71
85		1.17	1.170		133		4.73		
86		1.21			134		4.86		
87		1.24			135		5.00	5.070	
88		1.28			136		5.14		
89		1.32			137		5.29		
90	1.18	1.36	1.360		138		5.44		
91		1.40			139		5.59		
92		1.44		1.42	140	5.15	5.74	5.770	
93		1.48			141		5.90		
94		1.53			142		6.05		6.10
95		1.58	1.640		143		6.21		
96		1.63			144		6.37		
97		1.68			145		6.53	6.600	
98		1.74			146		6.70		
99		1.80			147		6.87		
100	1.6	1.86	1.860		148		7.05		
101		1.92			149		7.23		
102		1.98		1.96	150	6.72	7.42	7.530	
103		2.04			151		7.61		
104		2.11			152		7.81		7.90
105		2.18	2.100		153		8.01		
106		2.25			154		8.20		
107		2.32			155		8.40	8.500	
108		2.39			156		8.60		
109		2.46			157		8.81		
110	2.25	2.53	2.456		158		9.02		
111		2.60			159		9.24		
112		2.68		2.66	160	8.65	9.46	9.600	
113		2.76			161		9.68		
114		2.84			162		9.91		10.05
115		2.92	2.810		163		10.15		
116		3.00			164		10.41		
117		3.08			165		10.68	10.800	
118		3.16			166		10.96		
119		3.25			167		11.25		
120	3.0	3.33	3.300		168		11.54		
121		3.42			169		11.83		
122		3.50		3.58	170	11.05	12.13	12.050	
123		3.59			171		12.43		
124		3.69			172		12.73		12.72
125		3.79	3.830		173		13.02		
126		3.89			174		13.32		
127		4.00			175		13.62	13.550	

TABLE CONTINUED.

Temperature.	Force of vapour in inches of mercury.				Temperature.	Force of vapour in inches of mercury.			
	Robison.	Dalton.	Ure.	Southern.		Robison.	Dalton.	Ure.	Southern.
176°		13.92			221.6°			36.700	
177		14.22			222		36.25		
178		14.52			223		36.88		
179		14.83			224		37.53		
180	14.05	15.15	15.160		225		38.20	39.110	
181		15.50			226		38.89		
182		15.86		16.01	226.3			40.109	
183		16.23			227		39.59		
184		16.61			228		40.30		
185		17.00	16.900		229		41.02		
186		17.40			230	44.5	41.75	43.100	
187		17.80			230.5			43.500	
188		18.20			231		42.49		
189		18.60			232		43.24		
190	17.85	19.00	19.000		233		44.00		
191		19.42			234		44.78		
192		19.86		20.04	234.5			46.800	
193		20.32			235		45.58	47.220	
194		20.77			236		46.39		
195		21.22	21.100		237		47.20		
196		21.68			238		48.02		
197		22.13			238.5			50.30	
198		22.69			239		48.84		
199		23.16			240	54.9	49.67	51.70	
200	22.62	23.64	23.600		242			53.60	
201		24.12			245		53.88	56.34	
202		24.61		24.61	248.5			60.40	
203		25.10			250	66.8	58.21	61.90	60.00
204		25.61			255		62.85	67.25	
205		26.13	25.900		260	80.3	67.73	72.30	
206		26.66			265		72.76	78.04	
207		27.20			270	94.1	77.85	86.30	
208		27.74			275		83.13	93.48	
209		28.29			280	105.9	88.75	101.90	
210	28.65	28.84	28.880		285		94.35		
211		29.41			285.2			112.20	
212		30.00	30.000	30.00	290		100.12	120.15	120.00
213		30.60			293.4				
214		31.21			295		105.97	129.00	
215		31.83			300		111.81	139.70	
216		32.46			305		117.68	150.56	
216.6			33.40		310		123.53	161.30	
217		33.09			312			166.25	
218		33.72			320		135.00		
219		34.35			330				
220	35.8	34.99	35.540		340				
221		35.63			343.6				240.00

Gg (S.)

Table

OF THE

Elastic Forces of the Vapours of Alcohol, Oil of Turpentine, and Petroleum or Naphtha, in inches of Mercury.—By Dr. URE.
(Phil. Trans. 1818.)

Alcohol (sp. gr. 0.813.)		Alcohol (specific gravity 0.813.)		Petroleum.	
Temp.	Force of Va- pour.	Temp.	Force of Va- pour.	Temp.	Force of Va- pour.
32°	0.40	193.3°	46.60	316°	30.00
40	0.56	196.3	50.10	320	31.70
45	0.70	200	53.00	325	34.00
50	0.86	206	60.10	330	36.40
55	1.00	210	65.00	335	38.90
60	1.23	214	69.30	340	41.60
65	1.49	216	72.20	345	44.10
70	1.76	220	78.50	350	46.86
75	2.10	225	87.50	355	50.20
80	2.45	230	94.10	360	53.30
85	2.93	232	97.10	365	56.90
90	3.40	236	103.60	370	60.70
95	3.90	238	106.90	372	61.90
100	4.50	240	111.24	375	64.00
105	5.20	244	118.20	Oil of Turpentine.	
110	6.00	247	122.10	Temp.	Force.
115	7.10	248	126.10	304°	30.00
120	8.10	249.7	131.40	307.6	32.60
125	9.25	250	132.30	310	33.50
130	10.60	252	138.60	315	35.20
135	12.15	254.3	143.70	320	37.06
140	13.90	258.6	151.60	322	37.80
145	15.95	260	155.20	326	40.20
150	18.00	262	161.40	330	42.10
155	20.30	264	166.10	336	45.00
160	22.60			340	47.30
165	25.40			343	49.40
170	28.30			347	51.70
173	30.00			350	53.80
178.3	33.50			354	56.60
180	34.73			357	58.70
182.3	36.40			360	60.80
185.3	39.90			362	62.40
190	43.20				

Table of the Expansion of Liquids from 32° to 212°, their bulk at 32° being supposed 1.

Liquids.	Authority.	Dilatation in Decimals.	Dilat. in vulg. frac.
Muriatic acid (sp. gr. 1.137)	Dalton . . .	0.06000	$\frac{1}{17}$
Nitric acid (sp. gr. 1.40)	Ditto . . .	0.11000	$\frac{1}{9}$
Sulphuric acid (sp. gr. 1.85)	Ditto . . .	0.06000	$\frac{1}{17}$
Alcohol	Ditto . . .	0.11000	$\frac{1}{9}$
Water	Ditto . . .	0.04600	$\frac{1}{22}$
Water saturated with com- mon salt	Ditto . . .	0.05000	$\frac{1}{20}$
Sulphuric ether	Ditto . . .	0.07000	$\frac{1}{14}$
Fixed oils	Ditto . . .	0.08000	$\frac{1}{13}$
Oil of turpentine	Ditto . . .	0.07000	$\frac{1}{14}$
Mercury	Ditto . . .	0.02000	$\frac{1}{50}$
Ditto	Ld. C. Cavendish	0.01872	$\frac{1}{54}$
Ditto	Shuckburgh, &c.	0.01852	$\frac{1}{54}$
Ditto	Gen. Roy	0.01680	$\frac{1}{60}$
Ditto	Hællstroem	0.01758	$\frac{1}{57}$
Ditto	Lalande . . .	0.01500	$\frac{1}{67}$
Ditto	Petit and Dulong	0.0180180	$\frac{1}{55}$

Dr. Young's Table of the Expansion of Water from the Experiments of Gilpin and Kirwan.

N. B. Denoting a degree of Fahrenheit's Thermometer, by f , the expansion of water, reckoning either way from $+ 39^\circ$, is nearly represented by $0000022f^2 - 00000000435f^3$.

Temp.	Observed Expansion.	Calculated.
30 G.	.00020	.00018
32 G.	.00012	.00011
34 G.	.00006	.00005
39 G.	.00000	.00000
44 G.	.00006	.00005
48 G.	.00018	.00018
49 G.	.00022	.00022
54 G.	.00049	.00048
59 G.	.00086	.00084
64 G.	.00133	.00130
69 G.	.00188	.00186
74 G.	.00251	.00251
79 G.	.00321	.00326
90 G.	.00491	.00513
100 G.	.00692	.00720
102 G.	.00760	.00763
122 G.	.01258	.01264
142 G.	.01833	.01859
162 G.	.02481	.02512
182 G.	.03198	.03219
202 G.	.04005	.03961
212 G.	.04333	.04322

Table,

BY DE LUC,

Exhibiting the Degrees marked upon Thermometers filled with different Liquids at the same Temperature.

N. B. To comprehend the meaning of this Table, it must be understood that different thermometers (each filled with the particular fluid marked at the tops of the columns, and each being divided into 80 equal parts between the freezing and boiling water points) are placed with their bulbs in the same vessel full of water, and that the water is gradually heated. Then when the mercurial thermometer is at 5°, 10°, 15°, &c. the surfaces of the fluids in the other thermometers will be found at the degrees which stand on the same levels. For instance, when the mercurial thermometer stands at 40°, the water thermometer will be found at 20.5°; the spirit thermometer at 35.1°; the oil thermometer at 39.2°, &c.

Mercury.	Olive oil.	Essential oil of chamomile.	Essential oil of thyme.	Alcohol capable of firing gun-powder.	Water saturated with common salt.	Water.
80.°	80.°	80.°	80.°	80.°	80.°	80.°
75	74.6	74.7	74.3	73.8	74.1	71.0
70	69.4	69.5	68.8	67.8	68.4	62.0
65	64.4	64.3	63.5	61.9	62.6	53.5
60	59.3	59.1	58.3	56.2	57.1	45.8
55	54.2	53.9	53.3	50.7	51.7	38.5
50	49.2	48.8	48.3	45.3	46.6	32.0
45	44.0	43.6	43.4	40.2	41.2	26.1
40	39.2	38.6	38.4	35.1	36.3	20.5
35	34.2	33.6	33.5	30.3	31.3	15.9
30	29.3	28.7	28.6	25.6	26.5	11.2
25	24.3	23.8	23.8	21.0	21.9	7.3
20	19.3	18.9	19.0	16.5	17.3	4.1
15	14.4	14.1	14.2	12.2	12.8	1.6
10	9.5	9.3	9.4	7.9	8.4	0.2
5	4.7	4.6	4.7	3.9	4.2	0.4
0	0.0	0.0	0.0	0.0	0.0	0.0
— 5				— 3.9	— 4.1	
— 10				— 7.7	— 8.0	

Table of the Expansion of solids by Heat.

N. B. The linear expansion by being heated from 32° to 212° Fahr. is here to be understood. The expansion in volume may be learned by multiplying the decimal quantities by three, or dividing the denominators of the vulgar fractions by three.

Substances tried.	Authority.	Dilatation in Decimals, + the origi- nal length.	Dilat. in vulgar fract.
Antimony - - - -	Smeaton - - - -	1.00108300	$\frac{1}{913}$
Bismuth - - - -	Ditto - - - -	1.00139200	$\frac{1}{718}$
Brass - - - -	Lavoisier and Laplace	1.00186671	$\frac{1}{533}$
— cast - - - -	Smeaton - - - -	1.00187500	$\frac{1}{533}$
— wire - - - -	Ditto - - - -	1.00193000	$\frac{1}{518}$
— 16, tin 1 - - -	Ditto - - - -	1.00190800	$\frac{1}{522}$
Copper - - - -	Lavoisier - - - -	1.00172244	$\frac{1}{581}$
— hammered - - -	Smeaton - - - -	1.00170000	$\frac{1}{588}$
— - - - -	Petit and Dulong -	1.00171821	$\frac{1}{583}$
Glass tube without lead (crown) - - }	Lavoisier - - - -	1.00087572	$\frac{1}{1143}$
— white barom. -	Smeaton - - - -	1.00083000	$\frac{1}{1202}$
— - - - -	General Roy - - -	1.00077615	$\frac{1}{1288}$
— rod - - - -	Ditto - - - -	1.00080787	$\frac{1}{1237}$
— English flint -	Lavoisier - - - -	1.00081166	$\frac{1}{1248}$
— crown - - - -	Ditto - - - -	1.00089760	$\frac{1}{1118}$
— tube - - - -	Petit and Dulong -	1.00086130	$\frac{1}{1116}$
Gold, Paris standard not softened - - }	Lavoisier - - - -	1.00155155	$\frac{1}{643}$
— pure - - - -	Ditto - - - -	1.00146606	$\frac{1}{683}$
Iron - - - -	Smeaton - - - -	1.00125800	$\frac{1}{798}$
Ditto - - - -	Petit and Dulong -	1.00118203	$\frac{1}{848}$
— cast (prism) -	General Roy - - -	1.00110940	$\frac{1}{901}$
— hammered - - -	Lavoisier - - - -	1.00122045	$\frac{1}{819}$
— wire - - - -	Ditto - - - -	1.00123504	$\frac{1}{812}$
Lead - - - -	Ditto - - - -	1.00284836	$\frac{1}{351}$
Ditto - - - -	Smeaton - - - -	1.00286700	$\frac{1}{348}$
Pewter, fine - - -	Ditto - - - -	1.002283	$\frac{1}{438}$
Palladium - - - -	Wollaston - - - -	1.0010000	$\frac{1}{1000}$
Platinum - - - -	Troughton - - - -	1.00099180	$\frac{1}{1003}$
Ditto - - - -	Borda - - - -	1.00085655	$\frac{1}{1167}$
Ditto - - - -	Petit and Dulong -	1.0088420	$\frac{1}{1131}$
Silver, Paris standard	Lavoisier - - - -	1.00190868	$\frac{1}{524}$
Ditto - - - -	Troughton - - - -	1.0020826	$\frac{1}{488}$
Solder, soft, lead 2, tin 1	Smeaton - - - -	1.0025080	$\frac{1}{398}$
— spelter (brass 2, } zinc 1 - - - - }	Ditto - - - -	1.0020580	$\frac{1}{488}$
Speculum metal - -	Ditto - - - -	1.00193300	$\frac{1}{517}$
Steel, hard - - -	Lavoisier - - - -	1.00107875	$\frac{1}{917}$

TABLE CONTINUED.

Substances tried.	Authority.	Dilatation in Decimals, + the origi- nal length.	Dilat. in vulgar fract.
Steel, hard - - -	Smeaton - - - -	1.00122500	$\frac{1}{8}$
— soft - - -	Lavoisier - - - -	1.00107956	$\frac{1}{8}$
— tempered - - -	Ditto - - - -	1.00123956	$\frac{1}{8}$
Tin, Falmouth - -	Lavoisier - - - -	1.00217298	$\frac{1}{8}$
— Malacca - - -	Ditto - - - -	1.00193765	$\frac{1}{8}$
— Grain - - -	Smeaton - - - -	1.00248300	$\frac{1}{8}$
Zinc - - - -	Ditto - - - -	1.00294200	$\frac{1}{8}$
— hammered half } inch per foot - }	Ditto - - - -	1.00301100	$\frac{1}{8}$

Table of Equivalents.

IN the following *Table of Chemical Equivalents*, which, under another view, may be considered as denoting the *relative weights of the atoms of bodies*, hydrogen is expressed by 1, and other bodies are referred to it as a standard. This appears to me more convenient than the employment of oxygen as the unit of comparison, because all bodies lighter than oxygen are, in the latter case, necessarily expressed by fractional numbers. It is easy, however, to reduce the one scale to the other by the rule of proportion. Thus to know what number would be equivalent, oxygen being supposed 1, 10, or 100, to any known number which refers to hydrogen as unity, say as 8 is to 1, 10, or 100, so is the known equivalent to the equivalent sought. And contrariwise, when we have a scale of numbers in which oxygen is represented by 1, 10, 100, &c., and would know what is the equivalent of any of those numbers, hydrogen being taken as unity, say as 1, 10, or 100 to 8, so is the given equivalent to the equivalent required.

In drawing up the table, I have had recourse to the best authorities both original and compiled. The most copious Tables hitherto published are those of Berzelius,* Dr. Thomson,† and Mr. Brande;‡ but in many instances, their numbers, as well as my own, are to be considered merely as approximations; and it is probable, that there are few numbers, which will not undergo alteration by the subsequent progress of chemical science. The table will be rendered much more useful, if accompanied by a *logometric sliding scale*, the application of which to this purpose was a happy invention of Dr. Wollaston. On the fixed part of this instrument may be inscribed, opposite to their equivalent numbers, the names of substances; but as it is not possible to include on a single scale

* *Essai sur la Théorie des Proportions Chimiques*, 8vo. 1819.

† *System of Chemistry*, vol. iv. 6th edit.

‡ *Quarterly Journal*, xiv. 49. This table is published also separately.

the names of all substances, those may be selected which are most important, and most likely to become subjects of reference. Or, by a little practice, a scale containing *numbers only* may be used with facility, the names of substances being in this case *imagined* to be placed on the fixed part of the instrument, opposite to their representative numbers. A scale, however, on which names are inscribed, is best adapted to beginners; and an instrument of this kind will be found capable of affording a great variety of information, important both to the scientific and practical chemist.

1. The quantity of any substance, which is equivalent to a given quantity of any other inscribed on the scale, may be learned by inspection. For example, by bringing 50 on the slider opposite to magnesia, or to its equivalent 20, it will be seen that 50 parts of that earth are equivalent to 70 lime, 120 potassa, &c.

2. It shows the quantity of each base, that is equivalent to a given quantity of any acid. Thus 50 on the slider being brought opposite to sulphuric acid, or to its equivalent 40, it appears that 50 parts of that acid saturate 25 of magnesia, 35 lime, 60 potassa, &c. In a similar manner, the scale indicates the quantities of different acids required to saturate each base; thus 50 parts of magnesia saturate 100 of sulphuric acid, 135 nitric, &c.

3. It enables us to determine by inspection the proportions of the components in a given quantity of any substance of known composition. Thus, by bringing 100 on the slider opposite to 72, the equivalent of dry sulphate of soda, we find 55.5 on the slider opposite to the equivalent of sulphuric acid, and 44.5 opposite to the equivalent of soda, numbers which together make up 100 of the salt.

4. It expresses not only the *proximate* but the *ultimate* elements of compounds. Thus, keeping the slider in the same situation as in the last case, we find 22.4 on the slider opposite to 16, the equivalent of sulphur, and 33.1 opposite to 24, the equivalent of 3 proportions of oxygen; and $22.4 + 33.1$ make up together 55.5 sulphuric acid. By reference to the equivalents of sodium and oxygen, we find also that 44 parts of soda are made up of 33.4 sodium and 11.1 oxygen.

5. The quantity of any substance, which we must take to decompose a given quantity of another by single elective attraction, is at once taught by the scale. Thus, if we wish to know the smallest quantity of sulphuric acid adequate to decompose 100 parts of chloride of sodium, by bringing 100 on the slider opposite to chloride of sodium or its equivalent 60, we find $66\frac{1}{2}$ on the slider opposite to 40, the equivalent of dry sulphuric acid; and opposite to 49, the equivalent of sulphuric acid of commerce, we find $81\frac{1}{2}$ on the slider. We must, therefore, employ $66\frac{1}{2}$ of the former or $81\frac{1}{2}$ of the latter. Again, to know the quantity of dry sulphate of soda, which would result if all the common salt were decomposed, we shall find 120 on the slider opposite to the dry sulphate or to its equivalent 72, and 270 opposite to the crystallized sulphate or to its representative number 162. In several cases, however, in order

to effect a complete decomposition, it is necessary to employ more than the equivalent quantity of the decomposing body.

6. The quantities of salts, each consisting of two ingredients, that are required for mutual decomposition, may be learned by a similar use of the sliding scale. Supposing, for instance, that we have 83 parts of sulphate of potassa, and wish to know the quantity of chloride of barium, required for their decomposition; bring 83 on the slider opposite to sulphate of potassa, or to 88, its representative; and opposite to 106, the equivalent of chloride of barium, we find 100 on the slider, which is the number required. The results of this decomposition may also be learned by examining the instrument when in the same situation of the slider; for, opposite to the equivalent of sulphate of baryta 118, we find on the slider 111, and opposite to chloride of potassium we find 71.5 on the slider, the two last numbers indicating the resulting quantities of the new compounds. Again, from the weight of a precipitate, it is easy to deduce the quantities of salts which have afforded it. Thus, if we had obtained by experiment 120 parts of dry sulphate of baryta, on bringing that number opposite to its equivalent 118, we see at once that they may have resulted from $89\frac{1}{4}$ of sulphate of potassa, and 108 of chloride of barium; and, moreover, that 120 parts of barytic sulphate are composed of 40.6 sulphuric acid, and 79.4 baryta; the sulphuric acid consisting of 16.5 sulphur and 24.1 oxygen, and the baryta, of 8.15 oxygen and 71.25 barium.

Other applications of the scale of equivalents are pointed out by Dr. Wollaston in a memoir, explaining its principle and uses, inserted in the Philosophical Transactions for 1814.

TABLE OF CHEMICAL EQUIVALENTS, OR ATOMIC WEIGHTS.

Acid, acetic real	50	Acid, hydro-cyanic, 1 cy. + 1	
crystallized, (1 water)	59	hyd.	27
arsenic	62	hydro-sulphurous	115
arsenious	54	hydro-fluoric	17
benzoic	120	hyponitrous, 1 nit. + 3 ox.	38
boracic?	22	hypophosphorous, 2 p. +	
carbonic, 1 c. + 2 ox.	22	1 ox.	32
chloric, 1 chl. + 5 ox.	76	hyposulphurous, 1 s. + 1	
chloriodic, 1 chl. + 1 iod.	161	ox.	24
chloro-carbonic, 1 c. ox.		hyposulphuric, 2 s. + 5 ox.	72
+ 1 chl.	50	iodic, 1 iod. + 5 ox.	165
chloro-cyanic.	62	malic	60
chromic, 1 chr. + 3 ox.	52	manganeseous	52
citric (dry).	58	manganeseic	60
crystals, (2 water)	76	molybdic	71
columbic?	152	molybdous	63
ferro-cyanic?	67	muriatic	37
fluoboric?	22	nitric (real) 1 n. + 5 ox.	54
fluosilicic	24	(sp. gr. 1.5) 2 water	72
formic	37	nitrous, 1 n. + 4 ox.	46
gallic	63	oxalic (dry)	36
hydriodic	126	crystals (4 water T.)	72
hydro-chloric	37	(3 do. Berz.)	63

Acid, perchloric, 1 chl. + 8 ox.	100	Arsenic, iodide of?	163
phosphoric, 1 p. + 2 ox.	28	sulphuret (orpiment)?	54
phosphorous, 1 p. + 1 ox.	20	(realgar)?	62
purpuric	44	Azote	14
pyro-uric	251	Barium	70
saccholactic	105	chloride of, 1 b. + 1 chl.	106
selenic, 1 s. + 2 ox.	56	iodide	195
succinic	50	peroxide, 1 b. + 2 ox.	86
sulphuric (dry) 1 s. + 3 ox.	40	protoxide, 1 b. + 1 ox.	78
sp. gr. 1.85 (1 wat.)	49	sulphuret	86
sulphurous, 1 s. + 2 ox.	32	Baryta, dry, 1 barium + 1 ox.	78
sulphocyanic	57	crystallized (20 water)	258
tartaric, dry, (67 T. & B.)	66	acetate, dry	128
crystals (1 water)	75	arseniate? dry	140
tungstic	120	arsenite? do.	132
uric?	100	binhyposulphite, 1 b. + 2 ac.	126
Alcohol, 4 ol. gas + 2 aq. vapour	46	biphosphate, dry	134
Alum, dry (286 T.)	260	carbonate, do.	100
crystallized, (511 T.)	22	chlorate, do.	154
water	458	chromate, do.	130
Alumina, (27 Phillips, 18 T.)	26	hydrate	358
sulphate	66	hydriodate, dry	204
Aluminum, (10 T. 19 Phillips)	18	iodate, do.	243
Ammonia	17	nitrate, crystd. (no wat.)	132
bicarbonate, 1 am. + 2 c. a.	61	oxalate, dry	114
carbonate, 1 am. + 1 c. a.	39	ferro-cyanate?	145
chlorate, dry	93	muriate, crystd. (2 wat.)	133
citrate, do.	75	phosphate, dry	106
fluoborate, do.	39	phosphite, do.	98
muriate, 1 am. + 1 m. a.	54	crystallized (1 water)	107
nitrate, dry	71	sulphate, dry	110
crystallized, 1 wat.	80	sulphite, do.	118
oxalate, dry	53	tartrate, do.	145
crystals, (1 wat.)	62	tungstate, do.	198
phosphate, dry	45	Bismuth	71
phosphite, dry	37	chloride, 1 b. + 1 chl.	107
succinate, dry	67	iodate	244
sulphate, dry	57	nitrate, dry	133
crystd. (2 wat.)	75	oxalate, do.	115
sulphite, dry	49	oxide	79
tartrate, do.	83	subsulphate, 3 ox. b. + 1 ac.	277
Antimony, (Br. 45)	44	sulphate, dry	119
chloride	80	sulphuret	87
deutoxide, 1 anty. + 1½ ox.	56	Borax	6
iodide	169	Boron?	6
peroxide, 1 ant. + 2 ox.	60	Cadmium	56
protoxide, 1 ant. + 1 ox.	52	chloride	92
sulphuret, 1 ant. + 1 s.	60	nitrate, dry	118
tartarized	288	oxide	64
Arseniate of potassa, dry	110	phosphate, dry	92
soda, dry	94	sulphate, do.	104
Arsenic	38	sulphuret, 1 c. + 1 s.	72
chloride of?	74	Calcium	20
H h (S.)		chloride	56
		fluoride (fluor spar)	36
		oxide (lime)	28

Calcium, phosphuret of	32	Cyanogen, 1 nitr. + 2 carb.	26
sulphuret	36	Ether, sulphuric, 4 ol. gas + 1	
Calomel, see Mercury, protochloride.		aqueous vapour	37
Carbon	6	muriatic, 1 ol. gas + 1 m. a.	44
bisulphuret, 1 car. + 2 s.	38	chloric, 1 ol. gas + 1 chl.	43
hydriodide	139	Fluorine?	16
hydrochloride	43	Glucina	26
oxide (gas) 1 c. + 1 ox.	14	Glucinum	18
perchloride, 2 c. + 3 chl.	120	Gold?	200
protochloride, 1 + 1	42	chloride	236
subchloride, 2 + 1	48	iodide	325
Carburetted hydrogen, light, 1		protoxide, 1 gold + 1 ox.	208
car. + 2 hyd.	8	peroxide, 1 + 3	224
Carburetted hydrogen (olefiant)		sulphuret, 1 gold + 3 sul.	248
1 + 1	7	Gum, (Ure 68)	90
Cerium?	46	Hydrogen	1
protoxide?	54	Iodine	125
peroxide?	62	Iridium, (T.)	30
Chlorine	36	oxide	38
protoxide, 1 c. + 1 ox.	44	Iron	28
peroxide, 1 c. + 4 ox.	68	protochloride, 1 ir. + 1 chl.	64
Chromium	28	perchloride, 1 ir. + 1½	82
protoxide	36	protoxide, 1 ir. + 1 ox.	36
deutoxide (T.)	44	peroxide, 1 ir. + 1½	40
Cobalt, (26 T.)	30	persulphate, 1 perox. + 1½	
arsenate, dry	100	ac.	100
chloride	68	protosulphuret, 1 ir. + 1 s.	44
nitrate, dry	92	persulphuret, 1 + 2	60
oxalate, do.	74	subsulphate, 4 perox. + 1 ac.	204
peroxide, 1 c. + 1½ ox.	42	sulphate, dry, 1 prot. + 1 ac.	76
phosphate, dry	66	crystd. (7 wat.)	139
protoxide, 1 c. + 1 ox.	38	Lead	104
sulphate, dry	78	acetate (dry)	162
crystallized, (7		crystd. (3 water)	189
water)	141	arsenate, dry	174
sulphuret	46	carbonate, do.	134
Chloride of nitrogen, 4 c. + 1 n.	158	chloride	140
Columbium?	144	chromate, dry, 1 prot. + 1 ac.	164
Copper	64	bichromate, do. 1 + 2 ac.	216
acetate, 1 ac. + 1 perox.	130	deutoxide, 1 lead + 1½ ox.	116
crystd. (6 water)	284	gallate	175
binacetate, 2 ac. + 1 perox.	180	malate, dry	172
crystd. (3 water)	207	molybdate, do.	183
biphosphate, (2 water)	126	nitrate, crystd. (no water)	166
bisulphate, (blue vitriol)	160	nitrite	158
crystd. (10 water)	250	oxalate, dry	148
bisulphuret, 1 c. + 2 s.	96	peroxide, 1 lead + 2 ox.	120
binitrate, 1 perox. + 2 ac.	188	phosphate, dry	140
iodide	189	phosphite	132
perchloride, 1 c. + 2 chl.	136	protoxide, 1 lead + 1 ox.	112
protochloride, 1 c. + 1 chl.	100	subnitrate	278
protoxide, 1 c. + 1 ox.	72	subacetate, 3 protox. + 1 ac.	386
subnitrate, dry, 4 perox.		sulphate, dry	152
+ 1 ac.	374	sulphite, do.	144
subacetate, 2 perox. + 1		sulphuret	120
ac.	178	tartrate, dry	178
subsulphate, 2 perox. +		Lime, 1 calcium + 1 ox.	28
1	200	acetate, dry	78
Corrosive sublimate, see mercury		arseniate	90

Lime, binhyposulphite, (6 water)	130	Mercury, bichloride	272
biphosphate, dry	84	bicyanide	252
carbonate, do.	50	binitrate, 1 prot. + 2 ac.	324
chlorate, do.	104	bisulphate, dry	296
chloride, 1 + 1	64	bisulphuret	232
citrate, dry	86	iodide	325
chromate, do.	80	perchloride (corr. sub.)	272
hydrate, 1 + 1	37	peroxide, 1 + 2	216
hydrogd. sulphuret	89	protochloride (calomel)	236
iodate	193	protonitrate, 1 prot. +	
muriate	65	1 ac.	262
oxalate, dry	64	protosulphate, 1 prot.	
phosphate, do.	56	+ 1 ac.	248
phosphite, do.	48	protoxide, 1 + 1	208
subchloride, 2 l. + 1 chl.	92	sulphate	256
(6 water)	146	Molybdenum, (48 Br.)	47
sulphate, dry	68	protoxide	55
crystd. (2 water)	86	Morphia	322
tartrate	94	Nickel, (26 T. 30 B.)	40
(4 water)	130	acetate, dry	98
tungstate	148	arsenate, ditto	110
Lithia, (18 Br. & T.)	19	carbonate, ditto	62
carbonate	41	chloride, ditto	76
nitrate, dry	73	nitrate, ditto	94
phosphate	47	crystd.	
sulphate, dry	59	oxalate, dry	76
Lithium, (10 Br.)	11	peroxide, (38 T.)	52
chloride	47	protoxide, (34 T.)	48
sulphuret	27	sulphate, dry	88
Magnesia, 1 magnesium + 1 ox.	20	crystd. (7 wat.)	151
ammonia-phosphate	93	sulphuret	56
crystd. (5 wat.)	138	Nitric oxide, 1 n. + 2 o.	30
carbonate, dry, 1 + 1 ac.	42	Nitrogen	14
crystd. (3 wat.)	69	Nitrous gas, see nitric oxide.	
common	173	oxide, 1 n. + 1 o.	22
chloride, dry	56	Oil, olive?	79
hydrate, 1 + 1 water	29	Olefiant gas	7
muriate	57	Osmium?	
nitrate, dry	74	oxide	
phosphate, do.	48	Oxygen	8
sulphate, do.	60	Palladium?	56
crystd. (7 wat.)	123	oxide?	64
tartrate	87	Phosphorus	12
Magnesium	12	carburet	18
chloride	48	chloride	48
Manganese	28	perchloride	84
carbonate, 1 protox.		sulphuret	28
+ 1 ac.	58	Phosphuretted hydrogen, 1 p. +	
chloride, 1 m. + 1 chl.	64	2 hyd.	14
deutoxide (brown) 1		perphosphuretted,	
m. + 1½	40	1 + 1	13
oxalate dry,	72	Platinum	96
phosphate, do.	64	ammonia-muriate	222
protoxide, green, 1 m.		bisulphuret	128
+ 1 ox.	36	perchloride	168
tritoxide, 1 m. + 2 ox.	44	peroxide	112
sulphate, 1 protox. +		protochloride	132
1 ac.	76	protoxide	104
Mercury	200	sulphuret of	112

Potassa , dry, 1 potassium + 1 ox.	48	Soda , 1 sodium + 1 ox.	32
arsenate, dry (164)	110	acetate, dry	82
arsenite, do. (148)	102	crystd. (7 water)	145
bicarbonate, do. 1 + 2 ac.	92	arsenate, dry	94
crystd. (1 wat.)	101	arsenite, do.	86
binarsenate, dry	172	bicarbonate, do.	76
bichromate, do.	152	crystd. (2 water)	94
binoxalate, do. 1 + 2 ac.	120	carbonate, (sub-carb.) dry	54
biphosphate, do.	104	crystd. (10 wat.)	144
bisulphate, do.	128	chlorate, dry	108
crystd. (1 wat.)	137	chromate	84
bitartrate	180	hydrate	41
crystd. (1 wat.)	189	hydriodate, dry	158
chlorate, dry	124	iodate, do.	197
chromate, do.	100	nitrate, do.	86
citrate, do.	106	oxalate, do.	68
hydrate, solid (1 water)	57	sulphate, do.	72
hydriodate, dry	174	crystd. (10 water)	162
iodate, do.	213	sulphite, dry	64
molybdate, do.	120	tartrate, do.	98
muriate.	85	tartarized, 114 + 98	212
nitrate, dry	102	Sodium	24
oxalate, do. 1 + 1 ac.	84	chloride	60
perchlorate, do.	131	iodide	149
phosphate, do.	76	peroxide, 1 s. + 1½ ox.	36
quadoxalate, do. 1 + 4		protoxide, 1 s. + 1 ox.	32
ac.	192	Starch?	
succinate, do.	98	Strontia (55 Brande)	52
sulphate, do.	88	carbonate, dry	74
sulphite, do.	80	hydrate	61
tartrate, do.	114	muriate	89
tungstate, do.	168	nitrate, dry	106
Potassium	40	oxalate, do.	88
chloride	76	phosphate, do.	80
iodide	165	sulphate, do.	92
peroxide, 1 p. + 3 ox.	64	Strontium (47 Br.)	44
phosphuret 1 + 1	52	chloride	80
protoxide, dry, 1 + 1	40	oxide	52
subphosphuret, 2 + 1	92	Strychnia	380
sulphuret (various)		Sugar (Prout 75)	81
Rhodium?	44	Sulphur	16
protoxide?	52	chloride, 1 + 1	52
peroxide?	60	iodide	141
Selenium	40	phosphuret	28
Selenuretted hydrogen	41	Sulphuretted hydrogen	17
Silica	16	carbon, see carbon	
Silicium or silicon	8	Tannin	71
Silver	110	Tellurium	38
chlorate, dry	194	chloride	74
chloride, do.	146	oxide	46
iodate, do.	283	Tin	59
iodide, do.	235	bisulphuret	91
nitrate, do.	172	peroxide, 1 tin + 2 ox.	75
oxalate, do.	154	protoxide, 1 tin + 1 ox.	67
protoxide, 1 + 1	118	perchloride, 1 tin + 2 chl.	131
peroxide, 3 s. + 2 ox.	346	protochloride, 1 + 1	95
phosphate, dry	146	sulphuret	75
sulphate, do.	158	Titanium?	144
sulphuret of	126	Tungsten	96

Tungsten, bisulphuret	128	Zinc, iodate, dry	209
oxide, 1 t. + 2 ox.	112	nitrate, do.	95
Uranium?	125	oxalate, do.	77
oxide?	133	oxide	41
Water	9	phosphate, dry	69
Yttria	40	phosphuret	45
Yttrium	32	sulphate, dry	81
Zinc, (35 Br. 34 T.)	33	crystd. (7 water)	144
carbonate	63	sulphite, dry	73
chloride	69	sulphuret	49
hydriodate, dry	167	Zirconia	36
iodide	158	Zirconium	28

Table,

SHOWING THE

PROPORTIONS IN VOLUMES OF SEVERAL COMPOUNDS, WHOSE ELEMENTS ARE GASEOUS.

(N. B. A Table of the Specific Gravities of Gases may be found in this supplement, p. 15.)

Name.	Proportions in Volumes.	Resulting Volumes.
Air, atmospheric	4 Nitrogen + 1 oxygen . . .	5
Alcohol, vapour	1 Olefiant gas + 1 aq. vapour .	1
Ammonia	3 Hydrogen + 1 nitrogen . . .	2
Aqueous vapour (steam) . .	2 Hydrogen + 1 oxygen . . .	2
Carbonic oxide gas	2 Vapour of carbon + 1 oxygen .	2
acid do.	1 Ditto + 1 do.	1
Do. do.	1 Carbonic oxide + $\frac{1}{2}$ oxygen . .	1
Carburetted hydrogen gas .	2 Hydrogen + 1 carbon . . .	1
Carbonate, sub-, of ammonia	1 Carbonic acid + 2 ammonia .	(solid)
bi-, of do.	1 Ditto + 1 do.	ditto
sesqui-, of do.	$1\frac{1}{2}$ Ditto + 2 do.	ditto
Chlorine, protoxide of, gas	1 Oxygen + 2 chlorine . . .	$2\frac{1}{2}$
peroxide of, do.	2 Ditto + 1 do.	2
Chloric acid vapour	$2\frac{1}{2}$ Ditto + 1 do.	1
ether do.	1 Olefiant gas + 1 chlorine . .	
Chlorocarbonic acid gas . .	1 Carbonic oxide + 1 do. . . .	1
Chlorocyanic acid vapour .	1 Cyanogen + 1 chlorine . . .	2
Cyanogen gas	1 Nitrogen + 2 carbon . . .	1
Ether, muriatic, vapour . .	1 Muriatic acid gas + 2 alcoh.	2
sulphuric do.	2 Olefiant gas + 1 aq. vapour .	1
Fluoborate of ammonia . .	1 Fluoboric acid + 1 ammon . .	(solid)
sub- of do.	1 Ditto + 2 do.	ditto
Hydriodic acid gas	1 Hydrogen + 1 iodine . . .	2
Hydrocyanic acid vapour .	1 Cyanogen + 1 hydrogen . . .	2
Iodic acid	$2\frac{1}{2}$ Oxygen + 1 iodine . . .	(solid)
Muriatic acid gas	1 Hydrogen + 1 chlorine . . .	2
Muriate of ammonia	1 Muriatic acid + 1 ammonia .	(solid)
Nitric acid vapour	1 Nitrogen + $2\frac{1}{2}$ oxygen . . .	1
Nitrous acid do.	1 Ditto + 2 do.	1
Hyponitrous do.	1 Ditto + $1\frac{1}{2}$ do.	1
Nitrous gas	1 Ditto + 1 do.	2
oxide gas	1 Ditto + $\frac{1}{2}$ do.	1
Olefiant gas	2 Carbon + 2 hydrogen . . .	1
Phosphuretted hydrogen gas	2 Hydrogen + 1 phosphorus . .	$1\frac{1}{2}$
Biphosphuretted do. . . .	1 Ditto + 1 do.	1
Sulphuretted hydrogen gas .	1 Sulphur + 1 hydrogen . . .	1
Sulphurous acid do. . . .	1 Ditto + 1 oxygen	1
Sulphuric acid vapour . . .	2 Sulphurous acid + 1 oxygen .	2
Sulphuret of carbon vapour	1 Carbon + 2 sulphur	2

Table,

SHOWING THE

COMPOSITION OF SEVERAL OF THE PRINCIPAL MINERAL WATERS.

[N. B. The temperature, when not expressed, is to be understood to be 49° or 50° Fahrenheit.]

I. CARBONATED WATERS.

SELTZER. Bergman.

In each wine pint.

Carbonic acid	17 cub. in.
Specific Gravity 1.0027	
Carbonate of soda	4 grs.
of magnesia	5
of lime	3
Chloride of sodium	17
	29

CARLSBAD (Temperature 165° Faht.) Berzelius.

In a wine pint.

Carbonic acid	5 cub. in.
In 1000 parts by weight.	
Sulphate of soda	2.58714 grs.
Carbonate of soda	1.25200
Chloride of sodium	1.04893
Carbonate of lime	0.31219
Fluate of do.	0.00381
Phosphate of do.	0.00019
Carbonate of strontia	0.00097
of magnesia	0.18221
Phosphate of alumina	0.00034
Carbonate of iron	0.00424
Carbonate of manganese, a trace	
Silica	0.07504
	5.46656

SPA. Bergman.

Specific Gravity 1.0010.

In each wine pint.

Carbonic acid	13 cub. in.
Carbonate of soda	1.5 grs.
of magnesia	4.5
of lime	1.5
Chloride of sodium	0.2
Oxide of iron	0.6
	8.3

PYRMONT. Bergman.

Specific Gravity 1.0034.

In each wine pint.

Carbonic acid	26 cub. in.
Carbonate of magnesia	10. grs.
of lime	4.5
Sulphate of magnesia	5.5
of lime	8.3
Chloride of sodium	1.5
Oxide of iron	0.6
	30.6

POUGES. Hassenfratz.

In each wine pint.

Carbonic acid	30 cub. in.
Carbonate of soda	10. grs.
of magnesia	1.2
of lime	12.
Chloride of sodium	2.2
Oxide of iron	2.5
Silica	0.5
	28.4

COMPOSITION OF MINERAL WATERS,—CONTINUED.

II. SULPHURETTED WATERS.

AIX LA CHAPELLE. Bergman.

Temperature 143°.

In each wine pint.

Sulphuretted hydrogen. - 5.5 cub. in.

Carbonate of soda 12. grs.

— of lime 4.75

Muriate of soda 5.

21.75

CHELTENHAM, Sulphur Spring.

Brande and Parkes.

Specific Gravity 1.0085.

In each wine pint.

Carbonic acid 1.5 cub. in.

Sulphuretted hydrogen - 2.5

Sulphate of soda 23.5 grs.

— of magnesia 5.

— of lime 1.2

Muriate of soda 35.

Oxide of iron 0.3

65.

LEAMINGTON, Sulphur Water.

Scudamore.

Specific Gravity 1.0042.

Sulphuretted hydrogen, quantity not ascertained.

In each pint.

Muriate of soda 15. grs.

— of lime 7.96

— of magnesia 3.30

Sulphate of soda 11.60

Oxide of iron a trace

37.86

MOFFAT. Garnet.

Nitrogen 0.5 cub. in.

Carbonic acid 0.6

Sulphuretted hydrogen - 1.2

Muriate of soda 4.5 grs.

HARROGATE WATER.

New Well at the Crown Inn.

(West. Quart. Journ. xv. 82.)

Specific Gravity 1.01286 at 69°.

One wine gallon contains.

Sulphuretted hydrogen - 16.4 cub. in.

Carbonic acid 5.25

Azote 6.5

Carburetted hydrogen - 4.65

32.8

Also,

Muriate of soda 735. grs.

— of lime 71.5

— of magnesia 43.

Bicarbonate of soda 14.75

864.25

Old Well.

Sp. gr. 1.01324 at 60°.

Sulphuretted hydrogen - 14.0 cub. in.

Carbonic acid 4.25

Azotic gas 8.

Carburetted hydrogen - 4.15

30.4

Also,

Muriate of soda 752.0 grs.

— of lime 65.75

— of magnesia 29.2

Bicarbonate of soda 12.8

859.75

III. SALINE WATERS.

SEIDLITZ. Bergman.

Specific Gravity 1.0060.

In a pint.

Carbonate of magnesia 2.5 grs.

— of lime 0.8

Sulphate of magnesia 180.

— of lime 5.

Muriate of magnesia 4.5

192.8

CHELTENHAM, pure saline. Parkes and Brande.

Specific Gravity 1.010.

In each pint.

Sulphate of soda 14. grs.

— of magnesia 11.

— of lime 4.5

Muriate of soda 50.

80.5

COMPOSITION OF MINERAL WATERS,—CONTINUED.

LEAMINGTON, saline. Scudamore.

Specific gravity 1.0119.

In a pint.

Muriate of soda	53.75	grs.
— of lime	28.64	
— of magnesia	20.16	
Sulphate of soda	7.83	
Oxide of iron	a trace	
	110.38	

LEAMINGTON, Lord Aylesford's
spring. Scudamore.

Specific gravity 1.0093.

In a pint.

Muriate of soda	12.25	grs.
— of lime	28.24	
— of magnesia	5.22	
Sulphate of soda	32.96	
Oxide of iron	a trace	
	78.67	

BRISTOL. Carrick.

Temp. 74°. Specific gravity 1.00077.

In each pint.

Carbonic acid	1.5	cu. in.
Carbonate of lime	1.5	grs.
Sulphate of soda	1.5	
— of lime	1.5	
Muriate of soda	0.5	
Muriate of Magnesia	1.	
	6.0	

BATH. Phillips.

Temp. 109° to 117°. Sp. grav. 1.002.

In each pint.

Carbonic acid	1.2	cu. in.
Carbonate of lime	0.8	grs.
Sulphate of soda	1.4	
— of lime	9.3	
Muriate of soda	3.4	
Silica	0.2	
Oxide of iron	a trace	
	15.1	

BATH. Solid contents. Scudamore.

Muriate of lime	1.2	grs.
— of magnesia	1.6	
Sulphate of lime	9.5	
— of soda	.9	
Silica	.2	
Oxide of iron	.01985	
Loss, partly carb. of soda	.58015	
	14	

BUXTON. Scudamore.

Sp. gr. at 60°, 1.0006. Temp. 82°.

In a wine gallon.

Carbonic acid	1.5	cu. in.
Nitrogen	4.64	
Muriate of Magnesia	0.58	grs.
— of soda	2.40	
Sulphate of lime	0.6	
Carbonate of lime	10.40	
Extractive and vegetable matter	0.50	
Loss	0.52	
	15.	

Or, according to Dr. Murray's views,

Sulphate of soda	0.63	
Muriate of lime	0.37	
— of soda	1.80	
— of magnesia	0.58	
Carbonate of lime	10.40	
Extract and loss	1.02	
	15.00	

MATLOCK BATH. Scudamore.

Temp. 68° Sp. gr. .01003.

Free carbonic acid.

Muriates and } magnesia, lime, and
sulphates of } soda?

in very minute quantities not yet ascertained.

COMPOSITION OF MINERAL WATERS,—CONTINUED.

IV. CHALYBEATE WATERS.

TUNBRIDGE. Scudamore.

Specific gravity 1.0007.

In each gallon.

Muriate of soda	2.46
of lime	0.39
of magnesia	0.29
Sulphate of lime	1.41
Carbonate of lime	0.27
Oxide of iron	2.22
Traces of manganese, vegetable fibre, silica, &c.	0.44
Loss	0.13
	<hr/> 7.61

CHELTENHAM. Brande and Parkes.

Specific gravity 1.0092.

In a pint.

Carbonic acid	2.5 cub. in.
Carbonate of soda	0.5
Sulphate of soda	22.7
of magnesia	6.
of lime	2.5
Muriate of soda	41.3
Oxide of iron	0.8
	<hr/> 73.8

BRIGHTON. Marcet.

Specific gravity 1.00108.

Carbonic acid gas	2½ cub. in.
Sulphate of iron	1.80 grs.
of lime	4.09
Muriate of soda	1.53
of magnesia	0.75
Silica	0.14
Loss	0.19
	<hr/> 8.50

HARROGATE, Oddie's chalybeate.

Scudamore.

Specific gravity 1.0053.

In each gallon.

Muriate of soda	300.4
of lime	22.
of magnesia	9.9
Sulphate of lime	1.86
Carbonate of do.	6.7
of magnesia	0.8
Oxide of iron	2.40
Residue, chiefly silica	.40
	<hr/> 344.46

Table,

SHOWING THE

PRINCIPAL CHARACTERS OF THE EARTHS AND METALLIC OXIDES BEFORE THE BLOWPIPE.*

*. ABBREVIATIONS.—O. F. *Oxidating Flame*. R. F. *Reducing Flame*. = parts; *equal Parts of the Assay and Flux*. N. C. *Nitrate of Cobalt*. Fl. *Flaming*. C. *under the Column of either of the Fluxes means that the Support is Charcoal*. P. F. *Platina Foil*. P. W. *Platina Wire*. A Brace } refers to the Substances in the first Column only, and includes all those which are contained in the Space it comprehends.

ASSAY.	HEATED ALONE ON	
	PLATINA.	CHARCOAL.
Alkalies		
Baryta	Infusible	Infusible
Hydrate	Bubbles up and fuses	Is absorbed
Carbonate	Fuses readily into a clear glass; enamel-white on cooling	Becomes caustic, and is absorbed
Strontia	Infusible	Infusible
Hydrate	Like baryta	
Carbonate	Fuses with moderate heat at the surface, great brilliancy; tinges strong R. F. red; becomes alkaline	
Lime	No change	
Carbonate	Becomes caustic and alkaline; emits brilliant white light	
Magnesia	No change	No change
Alumina	No change	No change
Glucina	No change	No change
Yttria	No change	No change
Zirconia	Infusible: emits intense light	Infusible; emits intense light
Silica	No change	No change
Molybdic acid	F. fumes and fuses; brown-yellow on cooling; in R. F. blue; intense heat, brown	Fuses, and is absorbed, and partly reduced
Tungstic acid	R. F. blackens, but not reduced	The same
Oxide of chrome	No change	The same
Antimony		Fuses readily; white fumes, which condense into pearly crystals

* From Mr. Children's Translation of "The Use of the Blowpipe in Chemical Analysis and in the Examination of Minerals; by J. J. Berzelius."

ASSAY	HEATED ALONE ON	
	PLATINA.	CHARCOAL.
<i>Oxide of antimony</i>	Fuses readily, and sublimes, in white fumes; <i>precipitated oxide</i> , burns like tinder into antimonious acid	Fuses readily, and reduces: colours the flame greenish
<i>Antimonious acid</i>		Does not fuse, nor reduce; gives a bright light
<i>Antimonic acid</i>		Whitens; is changed to antimonious acid
Oxide of tellurium	F. fuses and fumes	Fuses, effervesces, and reduces
Oxide of columbium	No change	The same
Oxide of titanium	No change	The same
Oxides of uranium		Peroxide becomes protoxide; blackens, but does not fuse
Oxides of cerium	Protoxide becomes peroxide	Peroxide does not alter
Oxide of manganese		Not fused; becomes brown in a strong heat
Oxide of zinc	Yellow while hot; white when cold; does not fuse, but gives out great light when very hot, and white fumes, which condense like wool	
Oxide of cadmium	F. no change	Soon dissipates; leaves a red or orange-yellow powder on the charcoal
Oxide of iron	O. F. no change	R. F. blackens and becomes magnetic
Oxide of cobalt	No change	The same
Oxide of nickel	No change	The same
Bismuth		Flies off in fumes, and leaves a mark with red, or orange edges, which may be dissipated in R. F. without giving colour to the flame
<i>Oxide of bismuth</i>	F. fuses readily, mass dark-brown, yellowish on cooling. In very intense heat reduces, and perforates the foil	Instantly reduced
Oxides of tin	Protoxide takes fire, and burns like tinder into peroxide	R. F. peroxide does not fuse, but reduces in a strong prolonged heat
Oxide of lead	Minium becomes black while hot; at incipient redness, changes to yellow oxide, fusible into orange-coloured glass	Orange glass reduces into a globule of lead
Oxide of copper		O. F. black globule; flows over the charcoal; under surface reduces
Mercury		R. F. reduces; with strong heat gives a bead of metal
Oxide of silver	Instantly reduced	Instantly reduced
Gold		
Platina		
Iridium		
Rhodium		
Palladium		

ASSAY.	HEATED WITH FLUXES.		
	SODA.	BORAX.	SALT OF PHOSPHORUS.
Alkalies -----			
Baryta -----	} Fuse, and are absorbed by the charcoal	} Fuse readily with effervescence into a clear glass, which becomes opaque by Fl	} As with borax, but foam and intumescce; end in a clear glass
Hydrate -----			
Carbonate -----			
Strontia -----	No action on caustic strontia	} Like baryta	Ditto
Hydrate -----			
Carbonate -----	= parts, fuses into a clear glass, becomes milky on cooling; in strong heat, bubbles, and absorbed by the charcoal		
Lime -----	} No sensible quantity dissolved	Clear glass; opaque by Fl	Fuses in large quantity; clear glass
Carbonate -----		Fuses with effervescence; with more carbonate clear glass; crystallizes on cooling	Fuses with effervescence
Magnesia -----	No action	Like lime	Fuses readily; clear glass; saturated with magnesia, opaque on cooling
Alumina -----	Swells up: forms an infusible compound	Fuses slowly; permanently clear glass	Permanently clear glass
Glucina -----	No action	Clear glass, with a large proportion of the assay; opaque by Fl	As with borax
Yttria -----	Like glucina	Like glucina	Like glucina
Zirconia -----	Similar to glucina	Like glucina	Like glucina, but dissolves more difficultly
Silica -----	Fuses with brisk effervescence; clear glass	Fuses very slowly; permanently clear glass	Very small portion dissolves; clear glass
Molybdic acid ---	P. W. effervesces, clear glass; becomes milky on cooling C. fuses, absorbed and reduced	P. W. clear glass in O. F. C. and in R. F. glass becomes dirty-brown, but not opaque	P. W. and in O. F. greenish glass while hot; colourless, cold In R. F. becomes opaque; dull blue while hot; clear and fine green on cooling
Tungstic acid ---	P. W. dark-yellow glass, crystallizes on cooling; opaque white or yellowish C. and R. F. reduced	P. W. and O. F. clear glass; not opaque by Fl R. F. glass becomes yellow	C. same phenomena O. F. yellowish glass R. F. fine blue glass
Oxide of chrome --	P. W. and O. F. dark-orange glass; opaque and yellow on cooling R. F. opaque; glass green on cooling C. absorbed, but not reduced	C. fuses difficultly, glass emerald-green; on P. W. and O. F. the colour flies, and glass becomes brown-yellow; on cooling, assumes a faint-green tinge	Green glass in both flames
Antimony -----			

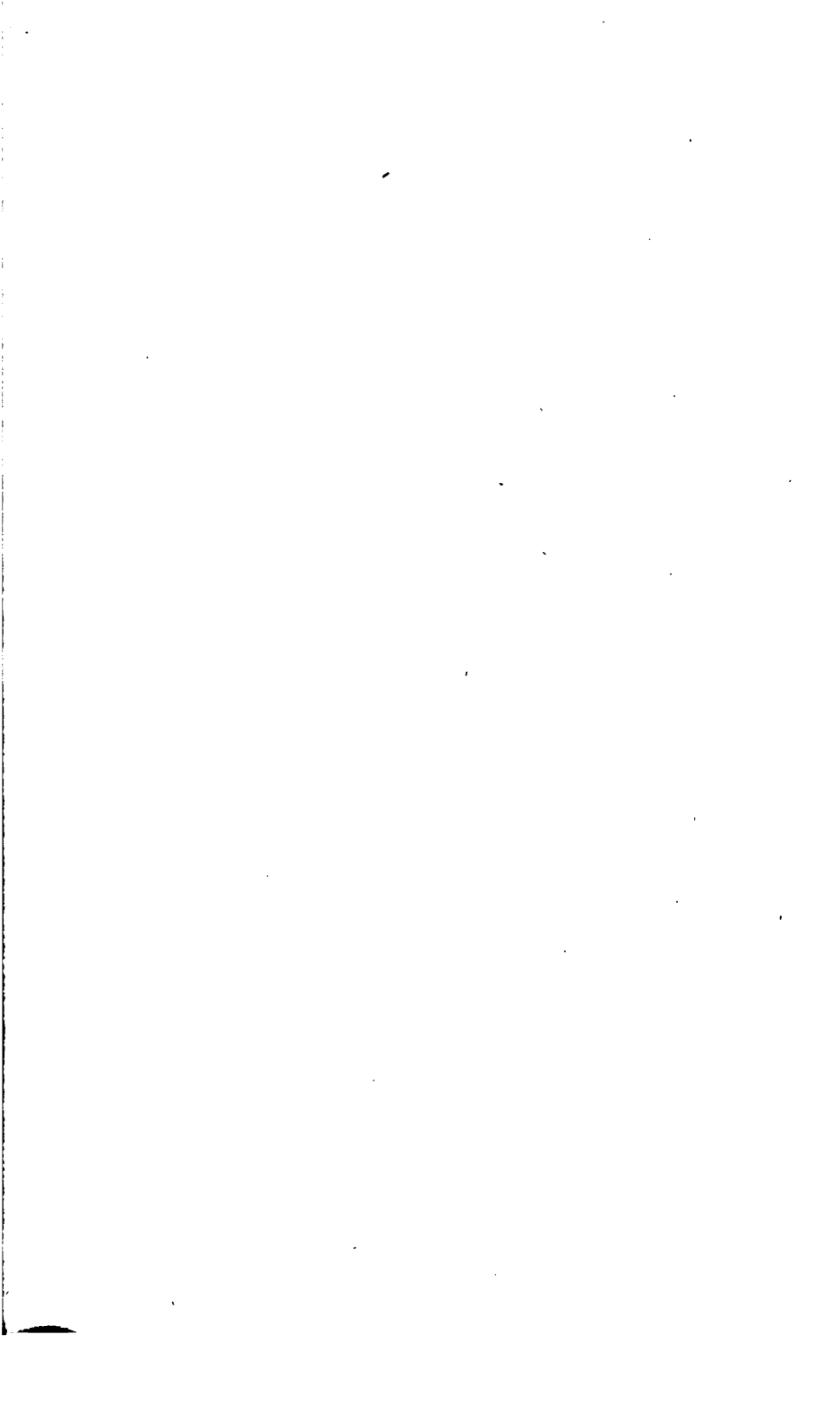
ASSAY.	HEATED WITH FLUXES.		
	SODA.	BORAX.	SALT OF PHOSPHORUS.
<i>Oxide of antimony</i>	P. W. fuses; clear colourless glass becomes white on cooling C. is reduced	C. dissolves in large quantity; glass yellowish, hot; almost colourless, cold. If saturated, part reduced and sublimed; strong R. F., the glass becomes opaque and grayish	P. W. and O. F. glass yellowish, hot; colour flies on cooling
<i>Antimonious acid</i> <i>Antimonic acid</i> - -			
<i>Oxide of tellurium</i>	P. W. colourless glass; white on cooling C. reduced	P. W. clear colourless glass; white on cooling C. becomes gray and opaque	The same
<i>Oxide of columbium</i>	Combines with effervescence, but not fused or reduced	Colourless, clear glass, becomes opaque by Fl	Fuses easily; glass permanently clear
<i>Oxide of titanium</i> -	Fuses into a clear dark-yellow glass; white or gray-white on cooling, and crystallizes with evolution of great heat C. not reducible	P. W. fuses, easily; glass, colourless; becomes milk-white by Fl R. F. glass assumes a dark amethyst colour, but transparent In large quantity on C. and R. F. glass, dull-yellow; when cold, deep-blue	O. F. clear, colourless glass R. F. and on C. glass, yellowish, hot; on cooling, first red, then very fine bluish-violet
<i>Oxides of uranium</i>	C. brown-yellow; not fused	P. W. dark-yellow glass; in R. F. becomes dirty-green	P. W. & O. F. clear yellow glass; cold, straw-yellow, slightly green C. and R. F. fine green glass
<i>Oxides of cerium</i> -	C. not fused, soda, absorbed; white or gray-white protoxide remains on the surface	O. F. fine red, or deep orange-yellow glass; colour flies on cooling; cold yellowish tint. Enamel white by Fl. In R. F. loses its colour	O. F. fine red glass colourless when cold; and quite limpid
<i>Oxide of manganese</i>	P. F. fuses, green glass, clear; cold, bluish-green C. not reduced	O. F. clear, amethyst colour glass; colour flies in R. F.	The same, but colour not so deep. In fusion in O. F. boils, and gives off gas; in R. F. fuses quietly
<i>Oxide of zinc</i> - - -	C. not fused, but reduced, with flame; white fumes, which cover the charcoal	O. F. fuses easily, clear glass becomes milky by Fl	Nearly the same
<i>Oxide of cadmium</i> -	P. W. not fused C. reduced, sublimes, and leaves a circular yellowish mark	P. W. yellowish glass, colour flies on cooling; on C. glass bubbles, cadmium reduced, sublimes and leaves yellow oxide	Dissolves in large quantity, clear glass; on cooling, milk-white
<i>Oxide of iron</i> - - -	C. absorbed and reduced; not fused	O. F. dull red glass becomes clear and yellowish, or colourless by cooling. C. and R. F. bottle-green glass, or bluish-green	Similar to borax

ASSAY.	HEATED WITH FLUXES.		
	SODA.	BORAX.	SALT OF PHOSPHORUS.
Oxide of cobalt - -	P. W. pale-red by transmitted light; gray, cold	Fuses readily, deep-blue glass	The same, the colour appears violet by candle-light
Oxide of nickel - -	C. absorbed and reduced; not fused	O. F. orange-yellow, or reddish glass; becomes yellow, or nearly colourless, on cooling	As with borax, but the colour flies almost wholly on cooling
Bismuth - - - - - <i>Oxide of bismuth</i> -		O. F. colourless glass R. F. partly reduced, muddy grayish glass	O. F. yellowish brown glass, hot; colourless, but not quite clear, cold R. F. clear and colourless glass, hot; opaque and grayish-black, cold
Oxides of tin - - -	P. W. effervesces, tumified, infusible mass C. readily reduced	Fuses with great difficulty; permanently clear glass	As with borax
Oxide of lead - - -	P. W. clear glass becomes yellowish and opaque on cooling C. instantly reduced	P. W. clear glass, yellow, hot; on cooling, colourless C. flows over the surface and reduces	Clear colourless glass
Oxide of copper - -	P. W. fine green glass, hot; on cooling, colourless and opaque C. absorbed and reduced	O. F. fine green glass, which in R. F. becomes colourless, hot; but cinabar-red and opaque when solid	O. F. similar to borax; R. F. glass usually red, opaque, and like an enamel
Mercury - - - - -		O. F. glass becomes milky, or opaline, on cooling	O. F. yellowish glass viewed by transmitted light by day, by candle-light reddish
Oxide of silver - -		R. F. grayish	R. F. grayish
Gold - - - - -			
Platina - - - - -			
Iridium - - - - -			
Rhodium - - - - -			
Palladium - - - -			

ASSAY.	WITH OTHER REAGENTS.	REMARKS.
Alkalies.		<i>The alkalies</i> are not readily distinguishable by the blowpipe. <i>Lithia</i> leaves a dull yellow stain; when heated to redness on platina foil. <i>Ammonia</i> may be known by heating the assay with soda: it gives off a pungent vapour, which turns the yellow colour of moistened turmeric paper brown
Baryta	} N. C.; a globule of different shades of red; colour flies on cooling	
Hydrate		
Carbonate		
Strontia	} N. C. exhibit a black, or grayish-black colour; do not fuse	
Hydrate		
Carbonate		

ASSAY.	WITH OTHER REAGENTS.	REMARKS.
Lime	} N. C. black or dark-gray mass,	
Carbonate		
Magnesia	N. C.; flesh colour when quite cold	
Alumina	N. C.; fine blue glass, with strong heat when cold	The blue colour is only distinctly seen by day-light
Glucina	N. C.; black or dark gray mass	
Yttria	N. C.; blue glass when perfectly fused	The part not perfectly fused with nitrate of cobalt, has a red-dish-blue disagreeable colour
Zirconia		
Silica		
Molybdic acid . . .		
Tungstic acid . . .		In the inclined glass tube, fuses, gives off vapour, which condenses, partly on the tube as a white powder, partly on the assay in brilliant pale-yellow crystals
Oxide of chrome . .		If tungstic acid contain iron, the glass with salt of phosphorus is blood-red in R. F. Tin makes it green or blue
Antimony		Antimony does not sublime at the fusing point of glass. On charcoal, when red, ignition continues spontaneously. In a tube open at both ends, it gives off white fumes
Oxide of antimony	}	{ The oxide and acids of antimony behave alike with the fluxes
Antimonious acid		
Antimonic acid		
Oxide of tellurium .		
		Metallic tellurium heated in a glass matrass, first gives off vapour, and then a gray metallic sublimate of tellurium. In a tube open at both ends, emits abundant fumes which condense in a white fusible powder
Oxide of columbium	N. C. black, or grayish-black	For the rest of the phenomena, see the original work.
Oxide of titanium .		
Oxides of uranium .		A very minute portion of manganese gives a green glass with soda
Oxides of cerium . .		
Oxide of manganese		
Oxide of zinc		The reduction of iron from the peroxide to protoxide is facilitated by tin
Oxide of cadmium .		
Oxide of iron		
Oxide of cobalt . . .	With subcarbonate of potassa, black glass when cold	In a glass matrass does not sublime at the fusing point of glass. In an open tube scarcely gives off any fumes; the metal becomes covered with a dull-brown fused oxide, of a slight yellowish tint, when cold
Oxide of nickel . . .		
Bismuth		

ASSAY.	WITH OTHER REAGENTS.	REMARKS.
<i>Oxide of bismuth</i> . Oxides of tin Oxide of lead Oxide of copper . . Mercury		<p>{All the compounds of mercury are volatile; mixed with tin or iron filings, and heated in a glass tube, metallic mercury distils over</p>
Oxide of silver . . . Gold Platina Iridium Rhodium Palladium		<p>{ These metals have no action on the fluxes, which can only serve to detect the foreign metals they may be combined with. They are best examined by cupellation with lead</p>



DESCRIPTION OF THE PLATE.

FIGS. 1, 2, 3. Views of Mr. Newman's *Mercurio-pneumatic trough*, combined with a mercurial gazometer. The same letters refer to all three figures.

Fig. 1, is a front view; fig. 2, a section; and fig. 3, a view looking down from above into the cavity of the trough. A, the glass bell of the gazometer, shown about half full of gas; B, the exterior vessel of the gazometer. In fig. 1, the central solid part, which fills the cavity of the bell when depressed as far as it will go, is shown by dotted lines, as also is a small iron tube, on which the letter B stands. This tube conveys the gases from the small bell-shaped vessel E, in which they are first received, into the receiver A of the gazometer. In fig. 2, this tube is marked *b b*, and may be seen rising a little above the mercury, which is thus prevented from falling into it. In fig. 3, the termination of this pipe is marked by a circle, close to the letter C.

D, fig. 1. one of the sides of the cistern for containing mercury, at G the cistern has a semi-cylindrical cavity seen more distinctly in fig. 2. F is a small tube opening into the gazometer, and also under one of the small holes *i i i*, fig. 3. By means of this tube, a small portion of gas may, at any time, be transferred from the gazometer into a narrow test tube or other vessel. H is a deep circular cavity, or well, into which a long tube or jar may be occasionally immersed, when it is necessary to have the mercury at the same level within and without. I is a receiver into which gas is supposed to be passing from a retort heated by the spirit lamp N. This lamp, by means of a pillar and socket, may be raised or lowered at pleasure, and is secured at any desired height by a spring. K, a Volta's Eudiometer secured by an upright pillar L, in which is a spring to diminish the recoil on firing any gases. This is moveable, and is fixed when wanted to the side of the trough by the screws M. O O, a sheet iron tray, intended to collect any mercury that may be spilled out of the trough.

FIGS. 4, 5, 6, 7. The *compound blowpipe for compressed oxygen and hydrogen gases*, with the addition of a safety tube for preventing explosions. A, the barrel of the condensing syringe. B, the handle of the piston. C, a cock for closing occasionally the communication with a bladder filled with the mixed gases. D, a cock between the syringe, and the square copper box into which the gases are condensed. This box is marked E. F, a perforated metal cap fitted by a screw to the top of the box, and containing a pile of circular discs of wire gauze, seen in fig. 5, such as is used for the safety lamps. G, a cock to prevent occasionally the

escape of the condensed gases. H. a ball and socket joint, by means of which the jet I. of which there should be two or three of different sizes, can be turned in any direction.

The addition to the apparatus for preventing explosions is represented in fig. 5. within the copper box. The letter *d* is placed on a piece of brass tube closed at the bottom, and fixed air tight into the box. Into the bottom of this, is fixed a small pipe *a a*, covered at the upper extremity *a* by a piece of wire gauze, and opening into the brass tube by two or four holes. A circular flat valve, lined with silk or leather, which may be seen in the sketch, covers these holes, and prevents the passage of any thing backwards from the brass tube into the box E.

When the instrument is to be used, the common air should be exhausted from the box E. by means of the syringe, the box then filled with the gases; after which water or oil should be poured into the brass tube (the cap F being supposed removed) to about *e*. The gases may then be condensed into the box, and by their own elastic force will pass through the tube, the fluid, and the various screens of wire gauze, and will issue out at the jet. When the inflammation, by the use of a large jet, passes backwards, it is generally arrested by the discs of wire gauze; but if it pass these, it kindles only the gases in the brass tube, and does no harm; and the valve prevents the fluid from being propelled into the box.

Fig. 1.

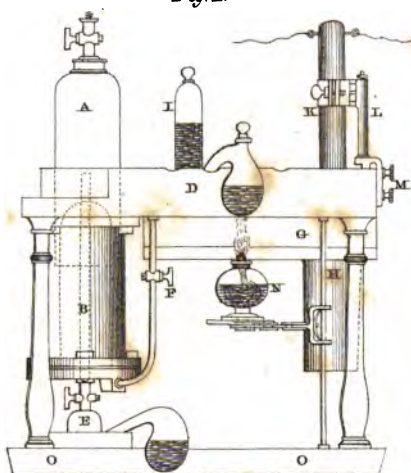


Fig. 2.

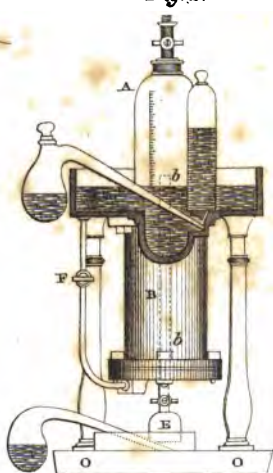


Fig. 3.

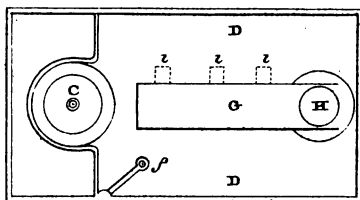


Fig. 6.

Fig. 7.

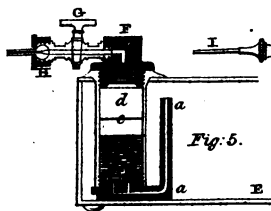
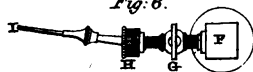
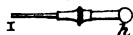


Fig. 5.

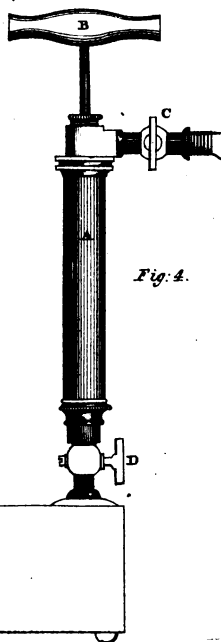


Fig. 4.

